A Conservation Assessment of the Northern Goshawk, Black-backed Woodpecker, Flammulated Owl, and Pileated Woodpecker in the Northern Region, USDA Forest Service

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Table of Contents

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The cooperation and support in developing this conservation assessment and detailed modeling work by Renee Lundberg is greatly appreciated. Jolyn Wiggins provided exceptional help in compiling Region-wide information that serves as one base for this conservation assessment. Jim Barber, William Tanke, and Bill Kirchhoff provided important and useful analytical and Geographic Information System support. Doug Berglund provided further assistance in the analysis of early forest inventory information and the comparison to current forest inventories.

The Conservation assessment of the northern goshawk, blacked-backed woodpecker, flammulated owl, and pileated woodpecker in the Northern Region, USDA Forest Service was mended March 6, 2006 for a slight change in the bootstrap approach implemented during the completion of the assessment. Revised habitat estimates for the northern goshawk and black-backed woodpecker are provided in Appendix 10 based on recommendations developed through the Wildlife Council.

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1. Introduction

This document is a conservation assessment for the northern goshawk, blacked-backed woodpecker, flammulated owl, and pileated woodpecker in the Northern Region of the USDA Forest Service completed between March 15 and July 20, 2005, with subsequent modifications.

The Forest Service is required by the National Forest Management Act (NFMA) to "provide for diversity of plant and animal communities based on the suitability and capability of the specific land area in order to meet overall multiple-use objectives." 16 U.S.C. 1604(g)(3)(B). To implement the NFMA, the Forest Service's regulations, implemented on January 5, 2005, state "The overall goal of the ecological element of sustainability is to provide a framework to contribute to sustaining native ecological systems by providing ecological conditions to support diversity of native plant an animal species in the plan area. This will satisfy the statutory requirement to provide for diversity of plant an animal communities based on suitability and capability of the specific land area to in order to meet overall multiple-use objectives." 36 C.F.R.219.10(b). Prior Forest Service regulations, implemented in 1982, provided that "Fish and wildlife habitat shall be managed to maintain viable populations of existing native and desired non-native vertebrate species in the planning area" 36 C.F.R. 219.19 (2000). The Forest Service's focus for meeting the requirement of NFMA and its implementing regulations is on assessing habitat to provide for diversity of species.

For each species, this conservation assessment consists of:

1) a brief overview of ecology, behavior, and habitat use;

2) a brief overview of the habitat use in the Northern Region;

3) estimates of well distributed habitat and habitat amount by National Forest;

4) evaluation of short-term (today's landscape) viability; and

5) evaluation of long-term viability (historic landscape) and ecosystem sustainability.

2. Summary - Methods and Background

This conservation assessment includes consideration of the peer-reviewed literature, non-peer-reviewed publications, particularly unpublished master's theses and PhD dissertations, research reports, and data accumulated by the Forest Service. Where possible, the peer-reviewed professional society literature is emphasized in that it is the accepted standard in science.

Major search engines in the literature review included use of three online line search engines:

Cambridge Scientific Abstracts [i.e., Agricola (3,651,000 citations as of October 2001), Biology Sciences (38,350 citations as of September 2003), and Environmental Sciences and Pollution Management (1,607,700 citations as of July 2004)];

WorldCat (52,000,000 records as of November 2004), a compilation of catalogs from libraries worldwide; and

Wildlife and Ecology Studies Worldwide, a compilation of references dating to 1935.

Literature published since 2000 was emphasized in that such recent publications review the previous literature and provide the best available and most recent science. Unpublished literature with a strong focus on unpublished master's theses and PhD dissertations provided information reflecting two to three year investigations into ecology, behavior, and or habitat requirements of the four species. Such unpublished university-based information was important to provide detailed information on species given the possible lack of studies published in the professional peer-reviewed literature. WorldCat served as the search engine to locate unpublished theses and dissertations.

Summary

This conservation assessment for the northern goshawk, black-backed woodpecker, flammulated owl and pileated woodpecker is based on a principle-based approach to population viability analysis (PVA). The methods and background for this principle-based approach using point observation data and vegetation inventory information based on Forest Inventory and Analysis (FIA) data was to build wildlife habitat relationship models to analyze short-term viability is discussed below. Also discussed below is the use of dispersal distance to assess the distribution of habitat and the consideration of long-term viability using the principles of Representation, Redundancy and Resiliency. The principle-based approach, using existing hard data, to develop this conservation assessment was utilized due to the limitations of population viability analysis in estimating minimum viable population numbers through either models or real numbers (Appendix 1). As explained, literature (Beissinger 2002) supports use of a principle based approach due to the lack of long-term demographic and environmental data. The focus should be away from a quantitative approach to PVA to an approach based on ecological principles widely agreed to in the peer reviewed professional society scientific literature. As background PVA models, as well as, the use of real data is discussed below prior to a discussion of the Region 1 principle-based approach to PVA.

Population Viability Analysis (PVA) Models

Beissinger (2002) in *Population Viability Analysis: Past, Present, and Future,* a book that summarized the results of an international symposium to address population viability analysis (PVA), described the history of the PVA field in four steps.

First, in 1981, Shaffer (1981) established a new direction for the field of PVA. Shaffer (1981) built on the earlier work by McCullough (1978), which predicted the future of the grizzly bear in the Greater Yellowstone Ecosystem. Shaffer's (1981) approach incorporated chance events, both demographic (largely variation in birth rates and death rates) and environmental stochasticity (effects of weather or other chance event), which led to estimating the minimum viable population (MVP) size that would persist with a given probability over a particularle length of time (Shaffer and Samson 1985).

Second, early application of the MVP concept (Samson 1983, Salwasser et al. 1984) explored the use of the concept as criteria to determine whether species should be listed under the Endangered Species Act (1973) and the converse, whether delisting was warranted (Beissinger 2002). The concept of risk (Salwasser et al. 1984, Samson et al. 1985) also was introduced to permit the relative evaluation of management actions as well as to begin to prioritize species for conservation.

Third, in 1981, Frankel and Soule's (1981) book *Conservation and Evolution* suggested a genetic-based approach to the MVP. From this book emerged the 50/500 (50 individual in the short-term/500 individuals in the long-term) rule which has become etched into the fabric of PVA (Beissinger 2002). Gilpin and Soule (1986) expanded the PVA concept using genetic and related information drawn from captive populations in zoological parks. Concurrent to Gilpin and Soule (1986) was the emergence of numerous and readily available software packages (VORTEX, RAMAS, ALEX and others) that greatly expanded the use of basic concepts (largely stochasticity and genetics) into PVA's.

Fourth, the ready availability of PVA software packages also illustrated the Achilles heel of PVA—the lack of long-term data to populate quantitative PVA models. Boyce (1992), Ralls and Taylor (1997), Beissinger and Westphal (1998), Groom and Pascal (1998), Reed et al. (1998) and others document the lack of long-term data and inability to accurately predict population trends without long-term demographic data. The lack or poor quality of data have lead to difficulties in parameter estimation, weak ability to validate any model, little understanding of the effects of alternative model structures in predicting population trends, and a need to shift to principle-based (Beissinger and Westphal 1998) rather than a quantitative approach to PVA.

Long-term demographic data is defined by the variance in death, birth, or other rates that do not tend to stabilize without 8 to 20 years of data collection (Beissinger and Westphal 1998, Morris et al. 1999) if at all (Pimm 1991). Rare environmental events—e.g., the 100-year drought or flood, fires, storms, unusually severe winters, and so on—also have large effects on variance estimates required in the use of PVA models (Ludwig 1996, 1999).

Shaffer et al. (2002) could find no example where a PVA model had been used to forecast the extinction of a wild population that occurred within the confidence limits of the model. Shaffer et al. (2002) further found no experimental tests of the commonly available models other than Belovski et al. (2002). Belovski et al. (2002) found the available models were inaccurate in terms of expected lifetimes (based on his laboratory populations of brine shrimp), but the underlying assumption that population lifetimes do depend on available habitat was, in essence, correct.

The lack of long-term demographic and environmental data had raised the question as to whether PVA was valuable to the field of species conservation (Beissinger 2002). The general conclusion was "yes" but change in focus and approach was required—away from "quantitative" or model-based approach to PVA to an approach based on ecological principles widely agreed to in the peer reviewed professional society scientific literature.

Real Studies to Determine Minimum Viable Populations:

Estimating the population density let alone population trend for most any vertebrate species is at best problematic (Bart et al. 2004). For example, four sources of bias in estimating bird density are 1) coverage, 2) closure, 3) surplus birds, and 4) detection rates.

Coverage refers to whether the population of interest is sampled in a way such that density estimates are possible. Often, the bias in such estimates is the difference in the trend in the area sampled and in the region-wide survey required to estimate trend (Bart et al. 2004). “The best approach for reducing bias due to incomplete coverage is probably to develop habitat-based models to extrapolate from surveyed to the nonsurveyed areas” (page 1244).

Double sampling is an approach to deal with closure or incomplete coverage. Double sampling is to conduct a broad-scale survey followed by smaller, more specific surveys to insure the accuracy of large-scale surveys but further the “application of double-sampling needs further investigation” (Bart et al. 2004:1245). Bart et al. (2004) “know of no cases in which these assumptions (i.e., all birds are recorded and no surplus birds are present) are necessarily true, and urge these assumptions be tested.”

Detectability is the requirement in a survey approach to estimate the numbers of birds (or other taxa under consideration) that each observer failed to detect. This is a significant issue. Failure to detect 10% of the birds in an area by an observer yields a very different density estimate than if the observer failed to detect 90% of the birds. Bart et al. (2004:1245) pointed out many surveys are conducted along roads, dikes, trails or other nonrandom locations and therefore are often “not representative of the study region.” Training of observers may help but is no substitute to the consideration of environmental characteristics which can vary substantially across the landscape.

Complicating the detectability of birds is the fact that males of many species cease to sing during the nesting season (Gibbs and Faaborg 1991). From an evolutionary viewpoint, it is advantageous to the paired male to feed its progeny and avoid attracting a predator to the nest area. Habitat based on singing males (versus that of a nest site) is just that, it may or may not be representative of habitat required to successfully nest and raise young.

Region 1 Principle-Based Approach to PVA Using Hard Data:

Point Observation Data Utilized

In November 2004 (McAllister 2004), a letter from the Regional Forester requested each Forest/Grassland to update their respective Point Observation Data (POD) so that it can be entered into FAUNA, the Forest Service’s corporate database for wildlife information. This letter served as a follow-up to a Regional request for POD for the goshawk in the summer of 2004.

Where available, POD were emphasized as the basis to build wildlife habitat relationship models, particularly to estimate the amount and distribution of habitat for each of the four species. Three of the four remaining criteria to evaluate the four species in this conservation assessment—human disturbance, biotic interactions, and managing for ecological processes—are primarily based on the recent peer-reviewed scientific literature.

In addition, for each Northern Region wildlife habitat relationship model developed for this conservation assessment, a bootstrap approach (Appendix 2) was used to provide an estimate of the standard error (SE). The SE is a relative measure of variability around the mean. A 90% confidence interval was selected and estimates of confidence limits and SE's for the estimates of each model are provided in Appendix 3.

FAUNA provides an up-to-date source of species information both to locate and describe high quality habitat to bridge the gap between single species management and ecosystem conservation. Currently, agreements are being developed to insure annual exchange of POD with the Montana Natural Heritage Program, The Nature Conservancy, Helena; Idaho Conservation Data Center, Idaho Department of Fish and Game, Boise; US Fish and Wildlife Service; Bureau of Land Management; and others from universities and elsewhere that collect POD.

POD is regularly used to build wildlife habitat relationship models (Peterson et al. 2002). Sergio and Newton (2003: 857) describe how 1) "Occupancy (POD) may be a reliable method of (habitat) quality assessment, especially for populations in which not all territories are occupied, or for species in which checking occupancy is easier than finding nests;" 2) "successful conservation should maintain or improve high quality (occupied) sites rather than focusing on poor (unoccupied) sites" (page 863); 3) occupancy data are often available, either by specific or amateur monitoring schemes; and 4) occupancy through space and or time is a reliable measure of territory quality, thus can provide key information for the development of conservation strategies.

Peterson et al. (2002: 619) suggest two additional advantages to use of POD in the development of models and conservation strategies, i.e., when updated from time to time, POD provide "for a continuously updated, never-out-of-date, growing database that builds in real time, thus taking advantage of a maximum of information for every result," and use of POD avoids the element of subjectivity when an expert (s) provides a range map, species account, or an ecological summary as the basis for a wildlife habitat relationship model.

Vegetation Inventory Information Used – FIA Data

Vegetation inventory information used to build the wildlife habitat relationship models and describe today's landscape is based on Forest Inventory and Analysis (FIA) data. FIA is the only congressionally mandated, comprehensive, field-based forest inventory for each of the 50 States, Puerto Rico, and Trust Territories. The McSweeney-McNary Forest Research Act (1928) defines the FIA mission: "Make and keep current a comprehensive inventory and analysis of the present and prospective conditions of and requirements for the renewable resources of the forest and rangelands of the United States."

FIA produces statistical reports and analytical information on status and trends in forest area and location; species, size, and health of trees; total tree growth, mortality, and removals by harvest; wood production and utilization rates for various products; and forest land ownership. As an example of its scientific stature, FIA maintains a bibliographic database of over 1,400 reports and scholarly papers dealing with FIA field surveys for the United States and its territories for the period 1975 through July 2001. These citations include integrated assessments and multi-disciplinary surveys, representative citations associated with timber resource assessments, and all known theses and dissertations associated with FIA data since 1975, regardless of topic.

In addition to FIA, estimates of forested habitat for each National Forest in the USDA Northern Region were developed. These estimates were developed using remote sensing (Appendix 4) and served only to provide estimates of forest (versus non-forest) habitat in that providing more detailed information (tree size, tree diameter, number of canopy layers and so on) is not obtainable through most forms of remote sensing.

Distribution of Habitat

Dispersal ability of young is the measure of well-distributed habitat (Thomas et al. 1990, Appendix P). In the President's Plan to conserve the oldgrowth forests of the Pacific Northwest, Thomas et al. (1992: 367) concluded for the spotted owl that "the distances between Habitat Conservation Areas should be within the known dispersal distances of at least two-thirds (67%) of all juveniles" in order to satisfy the 219.19 requirement for well distributed habitat. Subsequent modifications of the original Habitat Conservation Area network by the spotted owl recovery team also meet this criterion. The 9th Circuit Court has upheld the President's Plan.

Dispersal of young is an important component of population viability, yet is difficult to measure (Koenig et al. 2000). Researchers rarely look beyond their respective study areas to relocate banded birds or to recover dead birds. No broad-scale surveys exist to relocate banded birds and few telemetry-based studies are adequate in scope to address dispersal distances.

In an overall review of dispersal distance in birds, Bowman (2003: 198) found a relationship between median dispersal distance and the square root of territory size for a species that can be described as follows.

Median dispersal distance (in km) = 12 times the square root of the territory size (in ha).

The approach to dispersal distance in birds developed by Bowman (2003) is used in this conservation assessment for each of the four species.

Long-Term Viability

Shaffer et al. (2002), given the lack of progress in the demographic-based approaches to PVA, suggested a new direction to maintain MVP's over the long-term, one based on habitat and three ecological principles: 1) Representation, 2) Redundancy, and 3) Resiliency (the three R's). Representation is to provide representative examples of the natural landscape. Redundancy is to provide more than one example of the elements/natural landscape. Resiliency is to take into account environmental variation due to ecological processes. Employing these three principles "would acknowledge both what we do know about the determinants of long-term persistence and the limits of our forecasting ability" (Shaffer et al. 2002) whether in the short- or long-term.

Conservation of Ecosystem Diversity (full distribution of ecosystem characteristics) along with a comparison of the current condition of ecological processes to their pre-European settlement frequency and extent in the 2005 Draft Directives to implement the 2005 Forest Service Planning Rule is based on the three R's. The three R's form along with a comparison to the pre-European settlement character of an ecosystem form the basis to evaluate long-term viability and ecosystem sustainability in this conservation assessment.

An understanding of the pre-European landscape is essential to understand the requirements for the long-term conservation of species (Haufler et al. 2002) and ecosystem sustainability (Holling 1992, Allen and Holling 2002).

Historic inventories are one of several sources of information that can be used to reconstruct a landscape (Foster et al. 1996). Between 1937 and 1948, detailed surveys of forested lands were conducted in Idaho and western Montana (Berglund 2005). Such historic forest surveys provide information of forest composition and structure and provide a basis to compare those forests to the composition and structure of forests today as sampled by FIA.

Assumptions and limitations of this Conservation Assessment include the following.

1) Methods to estimate canopy closure, forest structure, and dominant forest type may differ among the studies referred to in this assessment and from those used by the Forest Service to estimate these habitat characteristics.

2) This conservation assessment focuses on forested habitat and may underestimate habitat for a species such as the northern goshawk known to use open shrub lands.

3) FIA sample points affected within the prior 10 years by either timber harvest or fire are excluded in the estimates of habitat for the four species.

4) FIA does not adequately sample rare habitats.
Scientific names are provided in Appendix 5.

<u>Summary of Results</u>

This short-term viability assessment reflects those eological factors which now impact a species persistence (Appendix 1). This conservation assessment shows that short-term viability is not an issue in Region 1 for the northern goshawk, black-backed woodpecker, flammulated owl or pileated woodpecker. Viable populations in the short-term for these species will be maintained as there is no scientific evidence that the species are decreasing in number, there have been substantial increases in the extent and connectivity of forested habitat since European settlement, the level of timber harvest of the forested landscape in the Northern Region has been insignificant, and well-distributed and abundant habitat exists on today's landscape for these species.

In regard to long-term viability, this conservation assessment has found that long-term habitat conditions in terms of Representativeness, Redundancy, and Resiliency are "low" for all species. The assessment of long-term viability relates to the sustainability of habitat conditions in which the species have persisted for an extended period of time (>100 years). The reason for the "low" habitat assessment in the long-term is that habitat (landscape) changes have occurred and are occurring that are moving habitat away from historic habitats. Included in these landscape changes are loss of grasslands and the increases in intermediate-aged forests and the increased connectivity of the landscape. These increases in intermediate-aged forests and connectivity threaten key remaining elements of biodiversity, such as areas of old growth, as these areas no longer persist in fire-protected refugia but are embedded in a well-connected matrix of intermediate-aged forest that permits the rapid spread of fire and insect outbreaks with a spatial-temporal pattern unlike the historic landscape. The result is a low rating for habitat Representativeness, Redundancy and Resiliency in the long-term.

3. The Northern Region

The Northern Region of the USDA Forest Service includes land in North Dakota, South Dakota, Montana and northern Idaho. The forested portions of the Northern Region are largely in Montana and northern Idaho and forested area by National Forest as estimated by remote sensing (Appendix 4) is summarized Table 1.

The National Forests in the Northern Region in terms of landform, pattern in precipitation, and vegetation are described by three Ecological Provinces (Bailey 1996): 1) the Northern Rocky Mountain-Steppe – Coniferous Forest – Alpine Meadow Province (NRMEP) by low relief mountains, with cedar-hemlock-pine, spruce-fir, and western ponderosa pine forests, and precipitation 64-250 cm; 2) the Middle Rocky Mountain Steppe (MRMEP) – Coniferous Forest – Alpine Meadow Province by low relief mountains, Douglas-fir, spruce-fir, ponderosa pine, and lodgepole forests, foothills prairie, sagebrush step, and alpine meadows, and precipitation 64 to 115 cm; and 3) the Southern Rocky Mountain Rocky Mountain Steppe (SRMEP) – Coniferous Forest – Alpine Meadow Province by steep, dissected mountains, Douglas-fir, spruce-fir, ponderosa, and lodgepole pine forests, and precipitation 120 to 280 cm.

In 1999, a coalition of national conservation organizations lead by T. H. Rickletts, World Wildlife Fund, evaluated and ranked the conservation status of each Ecological Province (Bailey 1996) in North America. The criteria developed by Rickletts et al. (1999) to evaluate the conservation status for each Ecological Province in North America were 1) Globally Outstanding (most important), 2) Regionally Outstanding, 3) Bioregionally Outstanding, and 4) Nationally Important. In addition, current conditions of each Ecological Province were rated by Rickletts et al. (1996) as Critical, Endangered, Vulnerable, and either Relatively Stable or Relatively Intact.

In the Northern Region (Rickletts et al 1999, appendix E, pages 135-145), remnant central tall grass prairie in North Dakota was considered to be Globally Outstanding and Critical—the highest of both ratings. Montane valley grassland, northern mixed prairie and shortgrass prairie were considered to be Nationally Important and Vulnerable in North America—a very significant rating. Northern Rocky Mountain forests were of Bioregional Importance and Vulnerable, and required either protection of remaining habitat or extensive restoration—a relatively low conservation rating in comparison to that on a global or national basis.

Today, in the Northern Region, more forest exists than at the time since European settlement. Gallant et al. (2003: 385) in the Greater Yellowstone Ecosystem found " the primary forest dynamic in the study area is not the fragmentation of conifer forest by logging, but the transition from a fire-driven mosaic of grassland, shrub land, broadleaf forest, and mixed forest communities to a conifer-dominated landscape." Area of conifer-dominated landscapes increased from 15% of the study area in the mid 1850's to 50% in the mid 1950's. Moreover, "substantial acreage previously occupied by a variety of age classes has given way to extensive tracks of mature forest" in the Greater Yellowstone Ecosystem.

In *Before Lewis and Clark,* Nasatir (1952) described the extensive network of trade established by the French, Spanish and British with Native Americans reaching from the upper Midwest into the Southwest before the 1800s. Laroque's daily journal (1805) describes the plains along the

Powder River as "amazing how very barren the ground is between this and the lesser Missouri, nothing can hardly be seen but those *Corne de Racquettes* (prickly pear cactus). Our horse nearly starved." Below the mouth of the Powder, Laroque commented that smoke from prairie fires plagued them for three days (Laroque 1934:13). Lewis and Clark observed (in 1805) "The country on both sides of the Missouri from the tops of the river hills, is one continued fertile level plain as far as the eye could reach, in which there is not even a solitary tree or shrub to be seen" (cited in Coues 1893).

On November 16, 1803, in west-central Montana, Lewis observed the first sage grouse, suggesting that much of the pre-European landscape in the eastern part of Montana was grassland and not shrubland (Zwickel and Schroeder 2003). In southwest Montana, Lesica and Cooper (1992) suggested a large and irreversible conversion of grassland to shrubland occurred in the 1850s and 1860s as a result of intensive grazing by introduced domestic livestock (sheep and cattle). Both eastern and southwestern Montana appear to have experienced recent and European-induced irreversible ecosystem changes, from grassland to shrub/tree dominated landscapes.

Irreversible changes from grassland to shrub/tree-dominated landscapes are significant. "Grassland conversion to agriculture excluded fires because many historical surface fires in dry forests actually began on grassy benches, ridge tops, or valley bottoms adjacent to dry forests and woodlands, or in nearby shrub steppe communities, and then migrated into dry forests" (Hessburg et al. 2004: 5). Fire sensitive tree species historically were restricted to rocky or less productive areas where fuels were minimal (Gallant et al. 2003). Extension of conifers into grassland and other open habitat throughout the Rocky Mountains due to fire suppression has been documented (e.g., Gruell 1983).

In northern Montana, Habeck (1994:69), using General Land Office Records, found with the reduced frequency and influence of fire Douglas-fir "has made major gains in stand dominance over ponderosa pine and western larch, especially on north aspects: on south aspects, former savanna and grassland communities have experienced conifer invasions" (see also Arno and Gruell 1986).

Rollins et al. (2000), working in the Selway-Bitterroot Wilderness Area in central Montana and Idaho, also described how fire return intervals are longer relative to pre-European estimates and have resulted in changes in forest composition and structure. These authors further suggested that action is needed to return the Wilderness Area to a natural fire regime to prevent catastrophic wildfire (see also McCune and Allen 1985).

Rockwell (1917), Smith and Fischer (1997), Neuenschwander et al. (1999), and Zack (1994) provide a collective forest history for the northern portion of Idaho and provide estimates of changes in composition and structure on the Idaho Panhandle National Forests. The historic landscape by percent for the Idaho Panhandle Nation Forests is estimated to have included 15% to 50% shrub, seedling or saplings, 15% to 50% pole to medium sized trees, 15% to 35% mature forest, and 15% to 35% oldgrowth forest.

In 2003, Hessburg and Agee (2003: 44) provided a historic forest narrative (1800 to present) in the inland northwest (including northern Idaho and western Montana). Hessburg and Agee (2003) suggest several landscape-level changes since European settlement that have had fundamental impacts on today's forest composition and structure.

First, Hessburg and Agee (2003: 44) note "As with the native prairies of the Great Plains, the demise of the Inland Northwest grasslands represented one of the most biologically diverse biomes on the continent, and a significant reduction of native habitats."

Second, Hessburg and Agee (2003: 44) note there "were important shifts in land cover from early to late-seral coniferous species." Periods of high-grade logging and selection cutting and fire suppression that followed not only reduced the dominance of early seral species but increased the dominance of shade tolerant conifers like Douglas-fir, grand fir, and white fir in multiple, often dense understories. The overall effect was to make today's landscape more structurally and compositionally homogeneous.

Third, "The most widely distributed change in forest structure across the Interior Columbia Basin was sharply increased area and connectivity of intermediate (not new or old) forest structures" (Hessburg and Agee 2003: 44).

The increase in connectivity is a threat to the conservation of oldgrowth forest and riparian areas (Hessburg and Agee 2003: 44). Historically, oldgrowth forest occupied semi-predictable fire refugia (Camp et al. 1997). Today, oldgrowth forests no longer occupy natural refugia from fire but exist in a matrix of well-connected forest intermediate in age. Hessburg and Agee (2003: 44) suggest "long-term plans to reserve remaining late-successional and old forests are probably ill fated because these forests are susceptible to burning." Hessburg and Agee (2003: 50) further suggest custodial management of riparian areas by buffers will have long-term effects on the patterns of natural processes across the landscape.

Hessburg and Agee (2003) describe two additional recent changes to forest structure. First, an increase in dead tree and snag abundances for small and medium sized trees (12.7 to 40.4 cm diameter) is evident in the interior Pacific Northwest forests. This increase in small and medium sized trees is an influence on both the fuel load (increases) and connectivity (increases) of the landscape. Second, current forest patches have more understory layers; historic forest understories were largely absent and, if present, were composed of shrub and herbaceous species (and not trees).

In 2004, Schoennagel et al. (2004) published an in-depth review of the interaction of fire, fuels, and climate across the Rocky Mountain forests. Of the three major fire regimes—high severity, mixed severity, and low severity, only low severity and less so mixed severity fire are considered to be beyond the historic or natural range of variation.

High severity or stand-replacing fires are those defined by death of canopy trees (Schoennagel et al. 2004). High-severity fires normally burn the tree tops, are infrequent (every 300 to 400 years) and most often occur in the subalpine zone—from mesic spruce-fir forests to drier, dense lodgepole stands, and open areas of limber pine. Most tree species in this ecological zone are

Table 1. Summary of forest area (ha) by National Forest as estimated by remote sensing (Appendix 4) in the USDA Forest Service Northern Region.

Ecological Province/National Forest	Forested
NRMEP	4,342,224
Idaho Panhandle	952,982
Kootenai	716,021
Flathead	775,598
Lolo	796,111
Bitterroot	458,030
Clearwater	643,482
MRMEP	2,555,245
Beaverhead-Deerlodge	987,545
Helena	294,775
Lewis and Clark	510,198
Nez Perce	762,727
SRMEP	668,624
Gallatin	465,054
Custer	203,570
Region	7,566,093

Table 2. Summary of habitat (ha) available to the northern goshawk, black-backed woodpecker, flammulated owl, and pileated woodpecker by National Forest in the USDA Northern Region estimated by Redmond et al. (2001). Variables included in the wildlife habitat relationship habitat models for each species are included in the footnotes.

Ecological Province /National Forest	Northern goshawk[1]	Black-backed woodpecker[2]	Flammulated owl[3]	Pileated woodpecker[4]
NRMEP				
Idaho Panhandle	869,940	775,172	275,606	849,612
Kootenai	164,723	488,800	116,923	488,602
Flathead	167,516	316,155	51,810	316.027
Lolo	130,176	398,581	146,580	398,429
Bitterroot	212,130	280,137	163,923	280,020
Clearwater	58,787	587,954	201,329	587,716
MRMEP				
Beaverhead-Deerlodge	267,701	134,377	100,399	134,323
Helena	51,484	121,605	146,518	121,556
Lewis and Clark	73,697	140.114	46,413	140,057
Nez Perce	731,301	730,336	298,120	730,040
SRMEP				
Gallatin	85,914	11,519		11,431
Custer	25,779			

Table 2 continued

[1] Variables included mixed broadleaf forest, lodgepole pine, ponderosa pine, grand fir, western red cedar, western hemlock, Douglas-fir, western larch, mixed subalpine forest, mixed mesic forest, mixed xeric forest, mixed broadleaf and conifer forest, <40% slope, and high canopy cover.
[2] Variables included Douglas fir/lodgepole pine, mixed subalpine forest, standing burnt forest; and medium and high canopy
[3] Variables included mixed broadleaf forest, ponderosa pine, Douglas-fir, mixed xeric forest less than 2100m in elevation.
[4] Variables included mixed broadleaf forest, ponderosa pine, grand fir, western red cedar, western hemlock, Douglas-fir, western larch, Douglas-fir/lodgepole pine, mixed xeric forest, mixed broadleaf and conifer forest, conifer riparian, broadleaf riparian, and mixed broadleaf and conifer riparian; and medium or high canopy cover.

thin-barked and easily killed by fire. The historic/predicted relationship of fuel build-up and fire frequency is missing in high elevation subalpine forests.

Many low elevation ponderosa pines experience low intensity, ground level and frequent fire (Schoennagel et al. 2004). A review of low intensity fire suggests the historical fire regime (or interval between fires) has changed and is now more infrequent (Arno and Gruell 1983). Spatial and temporal variation in fuels is important to low intensity fire frequency.

Mixed severity fires are intermediate between high intensity fires and low intensity fires (Schoennagel et al. 2004). Both high and low intensity fire can occur in differing frequencies in mixed severity fire. Ponderosa pine, Douglas-fir, grand fir, and western larch, depending on their location, are subject to mixed severity fire. Forests under the historic influence of mixed severity fire may develop more homogeneous forest structure, resulting in larger patches of continuous and dense forest.

Table 2 provides a summary of Redmond et al.'s (2001) estimated habitat for the four species considered in this assessment. Estimated habitat for each species considered in this assessment according to Redmond et al. (2001) was abundant and widespread—35.5% of the Northern Region provides habitat for the northern goshawk, 41.5% of the Northern Region provides habitat for the black-backed woodpecker, 26.6% of the Northern Region provides habitat for the flammulated owl, and 41.5 % of the Northern Region provides habitat for the pileated woodpecker.

The wildlife habitat relationship models developed by Redmond et al. (2001) rely primarily on cover types and LandSat (Satellite) imagery. Beissinger and Westphal (1998) described limits to the usefulness of Geographic Information Systems (GIS) satellite imagery in the development of PVA-based strategies for rare species. For example, it is reported not possible to use satellite imagery to identify site- specific habitat attributes such as forest structure for the northern goshawk (McGrath et al. 2003) as one variable in the development of a conservation strategy. Sample-based information as from FIA can provide reliable estimates of forest structure as well as composition.

It is important to keep the following four points as background relative to the Northern Region and the four species considered in this conservation assessment.

1) Forested landscapes are neither a national priority in conservation nor are they a priority in conservation at the ecosystem level in the northern Rocky Mountain in comparison to other major vegetation types (i.e., tall grass prairie, mixed prairie, shortgrass prairie and montane valley grassland). That is, conservation organizations have identified prairie and grassland landscapes to be most at risk -- not forested landscapes (Rickletts et al. 1999). In forested landscapes, habitat maintenance and or restoration are important in the northern Rocky Mountains.

2) Forests have changed since European settlement (Hessburg and Agee 2003, Hessburg et al. 2004 and others): the area of forest has increased; fire regimes have lengthened in time interval and changed in pattern (larger and more intense at least in lower elevation forests); Douglas-fir, grand fir and other shade tolerant species have increased in abundance and distribution; intermediate but neither young or old forest structure are abundant and well-distributed; and increased connectivity of the forests is placing mature and late seral forest at risk. This is because areas such as old growth now no longer persist in fire-protected refugia but are embedded in a well-connected matrix of intermediate-aged forest that permits the rapid spread of fire and insect outbreaks with a spatial-temporal pattern unlike the historic landscape.

3) Among the three primary patterns in fire, the natural regime for low severity fire has changed (longer interval) in low elevation primarily ponderosa pine forest, and some change, particularly in low elevation mixed conifer forests, is reported in the natural regime for mixed severity fire (combination of low severity and high severity fire) (Schoennagel et al. 2004). Frequency and patterns in high severity fire characteristic to high elevations may still be within their natural range of variation.

4) Habitat for the four species considered in this assessment, as estimated by wildlife habitat relationship models developed by the Spatial Analysis Laboratory, University of Montana, Missoula (Redmond et al. 2001), is widely distributed and abundant by Ecological Province (Bailey 1996) and National Forest (Table 2) in the USDA Forest Service Northern Region.

4. Northern Goshawk

Ecology, Behavior and Habitat

The northern goshawk is a large forest raptor occupying boreal and temperate forests throughout the Holarctic (Penteriani 2002). The northern goshawk in North America breeds in forested areas from central Alaska, central Yukon, and southeast MacKenzie and southern Keewatin, east through much Ontario into Quebec, Labrador and Newfoundland; south from central Alaska along the Alexander Archipelago into California and west into Montana and Wyoming; and south into Arizona (as cited Squires and Reynolds 1997). In the midwest and eastern United States, the northern goshawk breeds south from Canada into northern Wisconsin, Michigan, and into New Jersey, New York, Connecticut, Massachusetts, Maryland and West Virginia (as cited Squires and Reynolds 1997).

Northern goshawk migration begins in late September and continues through November (USDI Fish and Wildlife Service 1998). The northern goshawk is a partial migrant with some birds remaining year-round in an area while others move to lower elevations or to wintering areas some distance from the breeding area (Squires and Reynolds 1997). Irruptive movements—larger than normal numbers moving to a new area—are known and are thought to reflect cycles in the numbers of prey such as ruffed grouse or snowshoe hare (Doyle and Smith 1994).

Pair formation and nest building usually begins in early April and egg laying occurs in April and May (Squire and Reynolds 1997). The female northern goshawk is larger than the male and defends the nest while the male forages for food. Size of the typical home range for the northern goshawk in North America varies from 500 ha to 4,000 ha depending on age and sex of the bird, the habitat, and the methodology used in collecting and analyzing the data (Kennedy 2003). From one to five alternate nests are constructed by the northern goshawk within the home range.

Based on band returns, young birds may travel considerable distances (mean = 181 km, range 52 to 442 km) with the dispersal beginning in September (Kennedy 2003). Such estimates of dispersal distances are often biased and less than reality (Koenig et al. 2000). Researchers rarely look beyond their respective study areas to relocate marked birds and broad-scale surveys to relocate marked birds that may travel some distance from an individual study area are virtually non-existent.

The understanding of winter habitats is limited (Squires and Ruggiero 1996, Good 1998) but they appear to use a greater variety of habitats than in summer (Stephens 2001).

Squires and Reynolds (1997) in *The Birds of North America No. 298* provide detailed information on breeding range, non-breeding range, migration, morphology, pair formation, courtship and copulation, nesting phenology, metabolism and temperature regulation, molts and plumages, and demographics. A second and detailed source of information on northern goshawk habitat, effect of disturbance, predation and competition, utilization for scientific and commercial purposes, and disease relative to the conservation and management in the western United States is in *The Northern Goshawk Status Review* (USDI Fish and Wildlife Service 1998). Included in the Fish and Wildlife Service document is a complete review of the scientific literature, habitat information obtained from landowners and federal agencies, information from internet websites, and timber harvest records from the Forest Service. Conclusions from the USDI Fish and Wildlife Service (1998) review included but are not limited to 1) habitat should be a collected in a standard manner, 2) regional-level standards and guides should be developed, and 3) the northern goshawk is not appropriate for use by the Forest Service as a MIS.

A third and recent Forest Service sponsored review of northern goshawk ecology, behavior and conservation was conducted through Colorado State University, Fort Collins, Colorado and for the central Rocky Mountains is by Kennedy (2003). Kennedy's (2003) review provided comprehensive information on northern goshawk systematics, distribution and abundance, activity patterns, habitat, feeding habits, breeding ecology, threats, and viability. Insufficient information was available to conduct a PVA due to lack of long-term demographic information according to Kennedy (2003). Beissinger and Westphal (1998) and Morris et al. (1999) provided criteria as to when demographic information is sufficient to use a demographic model as a quantitative approach to estimate viable population size.

Several internet websites provide further detailed information on northern goshawk ecology (e.g., Accessed March 20, 2005; <http:/nhp.nris.state.mt.us/mbd> and Accessed March 20, 2005; <http://imn.isu.edu/digitalatlas>).

Nesting

The understanding of habitat requirements for the northern goshawk in the interior Pacific Northwest and elsewhere is handicapped. Few studies have equally sampled all habitats and seral stages (Squires and Reynolds 1997). Providing broad and ecologically sound habitat recommendations based on studies that differ in sampling design require a meta-analysis (Gurevitch et al. 2001). No meta-analyses are available for the northern goshawk (Kennedy 2003). For these reasons, habitat recommendations are not available for the northern goshawk other than in general terms.

Studies in the southwest provide the most comprehensive understanding of the northern goshawk in North America. Beginning with Reynolds et al. (1991), three spatial scales are used to describe how breeding northern goshawks use southwestern landscapes: 1) a 10 to 12 ha nest area, with one to five alternative nests located in different stands within the nest area; 2) a 120 to 240 ha post-fledging area (referred to as the pfa), an area surrounding the nest and used by young from the time of fledging to independence; and 3) a 500 to 2100 ha foraging area used by the breeding pair to forage for prey.

In 2000, Hanauska-Brown (Table 3) evaluated a nest site model for the northern goshawk in central Idaho (see also Hanauska-Brown et al. 2003). The Hanauska-Brown (2000) model is pixel-based (using Forest Service LandSat satellite imagery for vegetation and US Geological Survey digital elevation models) and considered three variables: basal area; tree size; and canopy closure.

The Hanauska-Brown's (2000) habitat relationship model was validated using information from 39 nests in central Idaho (no data are provided that describe the 39 nests). The Hanauska-Brown

Table 3. Summary of key characteristics (mean ± SD unless otherwise noted, sample size in parentheses) of goshawk nest tree and nest site in recent studies in the United States and outside lands managed by the USDA Forest Service Northern Region.

	Idaho Hanauska-Brown (2000)	Arizona Joy (2002)	Arizona Reich et al. (2004)	Northwest McGrath et al. (2003)	Oregon La Sorte et al. (2004)
Tree size dbh (cm)				56.3 ± 2.5 (82)	68.3 ± 13.0 (120)
Tree height (m)				29.5 ± .89 (82)	
Canopy closure (%)	>60 (39)	62.5 ± 26.4 cv 47.2 (454)		53.1 ± 1.7 (82)	45.0 ± 12. (120)
Basal area (m^2/ha)[1]	598 ± 35[2] (39)	29.3 ±18.7 (454)	29.27 ± 18.67 (454)	40.6 ± 1.3 (82)	12.5 ± 46.0 (120)
Understory ($m^{2/}$ha)		56 ± .42 (454)	>8.0 (454)	Low stem exclusion[3] (82)	10.7 ± 9.2[4] (120)
Slope				Lower 1/3 (82)	9.6 ± 6.9 (120)
Aspect				2-369 (82)	

[1] Basal area is the area of a cross section of a tree measured at diameter breast height.
[2] Stand index measured based on average tree size and density and represents the density of trees that have a quadratic mean diameter of 25 cm and not basal area.
[3] See McGrath et al. (2003) for details.
[4] Measured by self-righting sighting tube.

(2000) model estimated 558,185 of 1.5 million ha (or about one-third) of central Idaho provided potential nesting habitat for the northern goshawk.

Hanauska-Brown et al. (2003) in their study of northern goshawks in central Idaho found goshawk productivity and survival were negatively affected by the presence of other raptors, particularly by the barred owl, a recent arriver to Idaho and known to be the cause for the decline of other species such as the spotted owl (Kelly et al. 2003). No specific habitat recommendations were provided by Hanauska-Brown et al. (2003) to protect the northern goshawk from the barred owl or other species.

Miller (2001) compared landscape history and northern goshawk nests on lands managed by the Forest Service on the Kaibab Plateau, northern Arizona, and the Grand Canyon National Park, managed by the National Park Service, northern Arizona. The size, shape and spatial distribution of forest patches on Forest Service lands (smaller and more fragmented) differed from those on the National Park lands (larger and more connected). Forest Service timber stands on average had 60% less basal area and 20% fewer trees than timber stands in the National Park. Nevertheless, a small sample size of northern goshawk nests on the National Park ($n = 1$) lands prevented quantitative comparison of northern goshawk habitat on Forest Service and National Park lands.

Differences in the landscape were due to timber harvest on Forest Service lands and to large "catastrophic" fires of National Park lands according to Miller (2001). Miller (2001:57) concluded "historic management of the National Park and National Forest has resulted in two landscapes that possess different landscape scale and composition and different forest structure attributes. Despite these differences, it is not clear whether ecosystem function or (northern goshawk) population dynamics on the Plateau is effected" by the different agency-specific histories in land management.

Joy (2002) (Table 3) in a study in northern Arizona used Gibbsian pairwise potential model (a Markov point process that can simulate both regular and aggregated patterns) to examine the relationship between habitat composition and structure and northern goshawk demographics. Habitat was defined as local biotic, climate, and edaphic conditions that make up the northern goshawk's environment. Joy (2002) found territorial behavior and not habitat was limiting the distribution and abundance of nesting northern goshawks.

"Good" northern goshawk habitat was defined by Joy (2002) as tree species, i.e., ponderosa pine and mixed consider, particularly when the ponderosa pine had high canopy closure (regression coefficient of 0.003), and flatter slopes (regression coefficient of – 0.373). Steeper slopes (regression coefficient of –0.044) and east-facing slopes (regression coefficient of 0.041) improved nest habitat in mixed conifer habitats. The presence of seedlings and or saplings was important and improved the estimate for all nest habitats (regression coefficients ranged from 0.039 to 0.128). Most "good" habitats had few openings but 14% of the "good" nest sites had openings within the nesting territory.

Reich et al. (2004) summarized studies in northern Arizona dating to the early 1990's (Reynolds et al. 1991). Northern goshawks preferred areas of ponderosa pine, mixed conifer, and deciduous dominated forest for nesting.

Reich et al. (2004: 111) (Table 3) provides a Gibbsian pairwise potential model "to describe the spatial variability among northern goshawk nests and their association with forest structure on the Kaibab National Forest's North Kaibab Ranger District in northern Arizona." The analysis included four topographic variables (elevation, slope, aspect and landform) and seven stand

Table 4. Summary of tree species used for northern goshawk nest for recent (>2000) studies of northern goshawk habitat in the United States outside of the USDA Forest Service Northern Region.

Nest tree	Arizona Reich et al. (2004)	Northwest McGrath et al. (2003)[1]
Douglas-fir		32
Ponderosa pine	116	27
Mixed conifer	8	
Spruce dominated	17	
Deciduous dominated	6	
Lodgepole		7
Western larch		22
Grand fir		4
White fir	1	4
Sugar pine		1

[1] Estimated from Figure 7 in McGrath et al. (2003).

structure variables: percent canopy closure; total basal area; proportions of ponderosa pine; spruce/fir; aspen in the total basal area; maximum height of understory vegetation; and the presence of seedlings or samplings.

The Reich et al. (2003) (Table 3) study is an important summary of findings emerging from a nearly two decade long study in Northern Arizona. Variables that emerged important to nest sites selected by the northern goshawk included dominant tree species, total basal area, and slope. The major conclusions offered by Reich et al. (2004) are two. First, active northern goshawk nest locations were abundant and randomly distributed across the Kaibab Plateau in northern Arizona. "This supports the supposition that the availability of locations with high potential for nesting is not limiting the goshawk population" (Reich 2004: 109). Second, territorial behavior and not habitat was setting the upper limit to nesting northern goshawk populations.

McGrath et al. (2003) (Table 3) used a use-versus-availability design to test the null hypothesis that northern goshawk nesting habitat did not differ from available habitat. McGrath et al. (2003) tested this hypothesis using concentric circles placed around known nest sites and randomly located sites. The nine concentric circles around a nest tree (1 ha) extending in size to that corresponding to a pfa (radius =736 m). McGrath et al. (2003) reported three important considerations in evaluating northern goshawk habitat: 1) habitat is multidimensional; 2) certain habitat characteristics are scale-specific; and 3) some factors interact within a particular scale.

McGrath et al. (2003) found northern goshawks nests in seven tree species (Table 4). Goshawks placed their nests within areas of stem exclusion (P = <0.0002) and used oldgrowth forest in proportion to availability for nest sites. Northern goshawk nests were strongly associated with lower slopes (P = <0.001), primarily on north facing slopes (P = <0.001), and were closer to areas of human disturbance (P = <0.0001) than random sites.

The 30 ha circles in McGrath's study of northern goshawk nest sites were associated with mid- to late-forest structure with a canopy closure of >50%, i.e., high stem exclusion and high understory reinitiating. Basal area and low topography interacted in the multivariate analysis suggestion a strong interaction in characterizing goshawk nest site selection (P = 0.103).

La Sorte et al. (2004) (Table 3) compared habitat use by sympatric red-tailed hawks and northern goshawks on the Kaibab Plateau in Northern Arizona. Encroachment by the red-tailed hawk into northern goshawk territories is considered to be a conservation concern. The pattern that emerged from this study is that habitat use by the red-tailed hawk and northern goshawk was distinctively different at the fine and midscale. The red-tailed hawk displayed more variation in habitat use with non-forested areas and step slopes important to their territories.

Northern goshawk territories were observed on more gentle slopes (P = <0.001) and more continuous forest cover (P=<0.001) as compared to the red-tailed hawk (La Sorte et al. 2004). Overall, in comparison to the red tailed hawk, variables that described a northern goshawk nest site included nest tree height (P = <0.001), mean crown height (P = <0.001) and total number of shrubs (P< = 0.001). La Sorte et al. (2004: 316) concluded "that the habitat associations of goshawks are regionally consistent within a particular environment" and, that "an important management goal should be to retain goshawk breeding habitat within the goshawk's range of association."

Post-fledging Area

Few authors have described habitats in the northern goshawk pfa (the mid- or landscape area around the nest) in comparison to that around a nest site. McGrath et al. (2003: 29) compared vegetation in concentric circles (10 to 30. 30 to 60, 60 to 83, 83 to 120, 120 to 150, 120 to 170m) placed around a nest. McGrath et al. (2003) concluded stand initiation was important in the 10 to 60m circles; evenness was greater in 60 to 150 m circles, and high stem exclusion was of importance in the 10 to 83m circles. McGrath et al. (2003) concluded at the landscape (pfa) scale, stand initiation was important and habitat had less contagion (i.e., connectivity) suggesting goshawks were selecting for greater distance between stands of the same seral stage. These results do show "the goshawk's reliance on specific habitat conditions for nesting decreases as distance from the nest increase" (McGrath et al. 2003: 48).

Joy (2002) established a series of five concentric circles [.15 km, .3 km, .6 km. 1.2 km (a small pfa), and 2.4 km] around a nest to evaluate nest site and pfa habitat in comparison to that in the concentric rings. Random and equal sized plots were established independent of the northern goshawk territories. The comparison of high quality territory to surrounding habitat in the concentric circles showed the proportion of ponderosa pine to be significant ($P = <0.011$) within the first two or nearby circles.

Joy (2002) found the proportion of mixed conifer in northern goshawk pfa's did not differ in any concentric circle from that measured in the random plots. The proportion of deciduous dominated habitat in good territories was significantly different in each of the five concentric circles ($P = <0.000$ to 0.010), i.e., to include the pfa. The proportion of openings for both low and high quality habitat differed from that observed in random sites in each of the five concentric circles ($P = < 0.000$ to 0.011) which suggested canopy closure is a factor in goshawk selection of nest sites and pfa's. The diversity of tree types was significantly different in concentric circle 2 or pfa ($P = <0.025$).

Daw and Destefano (2001) in Oregon conducted a detailed study of northern goshawk pfa's centered on 22 nests. At the pfa scale, Daw and Destefano's (2001) recommendations are to "maintain forest conditions intermediate between the high foliage volume and canopy cover of nest sites and more open foraging heights" (page 59). More specifically, the most abundant structure was dense canopy and middle-aged forest (37%) followed by dense canopy and late forest (29%). The least abundant pfa habitat was early forest (3%). The mix of age structures was important to protect young against predators, such as the great horned owl and red-tailed hawk.

La Sorte et al. (2004) examined the variance in selected traits important to northern goshawk nest sites and pfa's as measured in 23 concentric circles centered on both goshawk and red-tailed hawk nest sites. In general, nest site and pfa habitat characteristics (non-forest habitat, slope) remained relatively consistent (as measured by an odds ratio ± SE) out to a distance extending about 550 m from a northern goshawk nest site.

Foraging

Even fewer studies are available that describe northern goshawk foraging habitat in comparison to either nest or pfa habitat. Hargis et al. (1994) during a three-year study of northern goshawks in California tracked eight female and two male northern goshawks equipped with radio transmitters. The intent of the Hargis et al. (1994) study was to determine those features or landscape patterns that influence northern goshawk home range size and individual use. Hargis et al. (1994) concluded that an "emphasis should be placed on creating or maintaining vegetation diversity" (as compared to random sites) (page 66) and "that timber harvests be designed to create a juxtaposition of seral stages, including mature timber, rather than large tracks of homogeneous, mid-seral stages" (page 73).

Joy (2002) suggests with regard to habitat associated with northern goshawk territories that "the spatial arrangement of vegetation types within the foraging area does little to differentiate further higher from lower quality habitat. Stronger relationships are expected to emerge, however, using variables of forest structure (including horizontal and vertical measures) due to their influence on the access to and resource availability for prey" (Joy 2002: 209).

Bloxton (2002) in western Washington studied prey abundance and space use (nine territories) by the northern goshawk (17 birds equipped with radio telemetry packages) from 1996 to 2000. Northern goshawk hunting techniques was suggested to reflect an adaptation to landscapes composed of a diversity of habitat structures where a wide variety of prey would be available. Bloxton (2002: 1) concludes "use of telemetry allowed me to gain a comprehensive understanding of the effects of weather can have on space use and demography of a generalist predator….and…. weather effects may override habitat effects." Significant variation in goshawk occupancy, reproduction, survivorship, and population size within an area may reflect weather and not habitat condition.

Bloxton (2002) found northern goshawk foraging habitat to be similar to that reported in other studies (Good 1998, Hargis et al. 1994, Bier and Drennan 1997 and so on), i.e., larger trees with well-developed canopies and with adequate flight space beneath the canopy. The open flight space under the canopy is required in searching for and capturing prey by the northern goshawk.

In recent years, xeric forests throughout much of the Intermountain West have become overstocked with small diameter trees due to suppression of fire (Agee 1998). Bloxton (2002) suggests this condition has likely reduced the ability of northern goshawks to hunt in these forests, particularly in younger stands, where less space exists between the overstory canopy and the shade tolerant undertstory conifers.

Sonsthagen (2002) examined northern goshawk annual movements (36 females with radio transmitters) in northern Utah. The study of northern goshawk movements was coupled with use of microsatellite DNA to estimate gene flow. In fall, juvenile birds were able to disperse and successfully find new territories in other areas (Sonsthagen 2000). Sonsthagen (2002) found that resident northern goshawks (i.e., those that did not migrate) preferred habitats in winter similar to those used in summer. Migrant northern goshawks were able to move throughout the state. No consistent pattern emerged in use of forested corridors by the northern goshawk, i.e., some did and some did not use forested corridors. Distances traveled in winter by resident birds ranged 49.1 to 191.0 km and upwards to 618.3 km for migrants.

Drennan and Beier (2003) described northern goshawk habitat use in winter in northern Arizona on the Kaibab Plateau. These authors suggested goshawks that leave their respective territories (more often males) and move to lower habitats which have larger-abundant populations of prey. Those goshawks remaining within the territory select sites for moderately dense mature forests where their ability to capture prey is maximized. Drennan and Beier (2003) concluded by quoting Braun et al. (1996: 11) in *The Wildlife Society Technical Review of the Northern Goshawk* that "management of southwestern forests must involve an ecosystem/landscape approach and should not be narrowly focused on 1 species" (page 184), i.e., the northern goshawk.

Northern Region

Nest and Nest Sites

Northern goshawk nest-site characteristics in western Montana and northern Idaho may include moderate slopes (15-35%) with northerly aspects (Hayward and Escano 1989) (Table 5). Among other nest site characteristics, Hayward and Escano (1989) found canopy closure (coefficient of variation of 7%) and basal area (coefficient of variation of 18%) were the most consistent (Table 6). About 40% of the nests were on north facing slopes and all nests were within one km of a large forest opening. Distance to an opening was < 0.5 km for half of all nests.

In the summer of 1989 and 1990, Whitford (1991) compared old-growth Douglas-fir stands (n = 50) with Douglas-fir northern goshawk nest stands (n = 12) in order to evaluate the appropriateness of the goshawk as a MIS for oldgrowth Douglas-fir on the Lewis and Clark National Forest in central Montana. Overall, "old-growth forest stands supported older, larger dbh live trees with open canopies while goshawk stands had younger, smaller dbh live trees with dense canopies" (page 43). In addition, old-growth stands supported fewer but larger snags while the nest stands had more but smaller snags per ha. Old-growth stands also contained larger logs and more total downed log volume per ha than northern goshawk nest stands.

Patla (1997) examined northern goshawk nesting ecology (31 territories) and habitat in undisturbed and timber harvest areas on the Targhee National Forest, part of the Intermountain Region, US Forest Service (Table 5). Patla (1997) found 1) no statistical difference in the proportion of mature forest cover sampled within the nest area, pfa, or foraging area; 2) important nest tree characteristics to be height (P = 0.004), diameter (P = 0.001), elevation (P = 0.004), and slope (P = 0.027); and 3) occupancy of nesting territories was positively correlated to the amount of sage/shrub habitat within the post-fledging area and in the overall foraging area.

Clough (2000) studied 19 northern goshawk nests in the northern half of the Flint Creek range, Beaverhead-Deerlodge National Forest, in east-central Montana. Northern goshawk selection of tree species (Table 5) for nesting was dependent on species (P = 0.008). Size (P = <0.001) and height (P = <0.001) of the nest tree were important factors in goshawk nest site selection (Table 6). Nests were within 1 to 5 km of the grassland/timber interface, on north facing slopes (82.6%), independent in distance to water, and shared several environmental characteristics. On average, nest sites were dependent on aspect (P = <.0015) and near the edge of the nest stand (P = <0.001). All 19 nests had canopy closure >=50% with sapling density (P = <0.005) and density of large trees (P = <0.005) important.

Moser and Garton (2004) described the results of a telemetry-based northern goshawk study (n = 18) in northern Idaho. The 18 breeding areas (170 ha around the nest) studied by Moser and Garton (2004) included areas with timber harvest with a minimum of 11% (range 11-38%) of the breeding area disturbed by timber harvest (50-99% overstory removal within harvest boundary) and habitat in non-harvested controls (n = 9). Breeding areas were harvested in 2002 (n = 4) and 2003 (n = 5). Northern goshawks in all breeding areas successfully fledged young the year prior to treatment and productivity was the same between treatments prior to timber harvest.

Table 5. Number of nests by tree species by the northern goshawk for nest sites in the USDA Forest Service Northern Region.

Tree species	Idaho Patla (1997)	Montana Clough (2000)	Montana NRMEP (2004)	Montana MRMEP (2004)	Montana SRMEP (2004)
Douglas-fir	38	11	56	74	10
Ponderosa pine			12	13	18
Lodgepole	9	8	1	30	2
Western larch			34		
White pine			8		
Grand fir			5		
Paper birch			3		
Subalpine fir			1		
Aspen	1			5	
Western hemlock			11		
Engelmann spruce	1				

Timber harvest in the Moser and Garton (2004) study had no effect on northern goshawk breeding area occupancy, nest success, or productivity 1 to 2 years after timber harvest. Occupancy of harvested goshawk breeding areas was 89% and 75% after 1 year and 2 year, respectively, compared to 80% and 78% of the pairs after 1 year and 2 year, respectively. Northern goshawk nest success and productivity were influenced by spring weather rather than timber harvest. Moser and Garton (2004) concluded in northern Idaho that timber harvest does not appear to affect northern goshawk breeding area occupancy, nest success, or productivity 2 years after harvest as long as suitable nesting habitat remains within the breeding area.

POD for the northern goshawk on Forest Service lands in the Northern Region provide information on 374 nest locations in the Northern Region (Table 6). Either an adult, pair, and or young were observed either in or in very close proximity to a nest site.

Northern goshawks in the Northern Region nest in Douglas-fir (n = 141), ponderosa pine (n = 43), and lodgepole pine (n = 39) (Table 5). Selection of the 10 tree species as nest sites in the Northern Region (Table 5) is similar to tree species selected in other northern goshawk studies (Table 4).

Table 6. Summary of key characteristics (mean ± SD unless noted, sample size in parentheses) of northern goshawk nest trees and nest sites in or near the USDA Forest Service Northern Region.

	Hayward and Escano (1986)	Patla (1997)	Clough (2000)	NRMEP (2004)	MRMEP (2004)	SRMEP (2004)
Tree size dbh (cm)	Saw timber 12% (<35 cm dbh), mature 38% (>35 but <50 cm dbh), old forest 50% (>50 cm dbh) (17)	43.6 ± 25.0 (49)		36.39 ± 9.7 (23)	36.6 ± 5.8 (90)	31.8 ± 5.6 (9)
Tree height (m)		25.0 ±1.0 (49)				
Canopy closure (%)	80.0 ± 2.71 (17)	79.0 ± 3.0 (49)	66.7 ± 1.73 (19)	79.8 ± 12.2 (23)	52.4 ± 18.2 (90)	70.0± 10.3 (9)
Basal area (m^2/ha)[1]	40.6 ± 3.75 (17)	27.7 ± 1.5 (49)	49.8 ± 1.7 (19)	41.6 ± 15.1 (23)	41.8 ± 9.7 (90)	32.8 ± 8.8 (9)

[1] Basal area is the area of a cross section of a tree measured at diameter breast height and is a measure of density.

The diameter beast height (dbh) of trees used as nest sites by the northern goshawk varies from 10 to 76 cm with a mean of 35 cm (Table 6). The average dbh for a goshawk nest site in the POD is within the range of dbh reported for other nest trees by Clough (1990), Whitford (1991), Patla (1997) and others (Table 4).

The northern goshawk POD canopy closure estimates (Table 6) in general also are similar to those reported in recent studies (Table 4).

Post-fledging Area

Clough's (2000) analyses showed only 11.3 ± 5.1 % of the northern goshawk pfa's contained oldgrowth or mature forest. On average, 77% of the pfa's were covered by forest of which

Table 7. Nest site, pfa, and foraging northern goshawk habitat relationship models for the USDA Forest Service Northern Region.

	BA_WTD_DBH[1] (cm)	Dominance group[2]	Canopy coverage (%)	Basal area m^2/ha[3]	Structure class[4]
Nest model					
Regional	25.4-45.7	ABGR, ABGR-1MIX, ABLA, ABLA-1MIX, IMXS, LAOC, LAOC-1MIX, PIMO, PIMO-1MIX, PICO, PICO-1MIX, PIPO, PIPO-1MIX, PSME, PSME-1MIX, TGCH, TSHE, TSHE-1MIX, POTR5, POTR5-1MIX, BEPA, BEPA-1MIX	34-92	24-59	1, 2
NRMEP[5]	25.4-45.7	ABGR, ABGR-1MIX, ABLA, ABLA-1MIX, IMXS, LAOC, LAOC-1MIX, PIMO, PIMO3-1MIX, PIPO, PIPO-1MIX, PSME, PSME-1MIX, TGCH, TSHE, TSHE-1MIX, POTR5, POTR5-1MIX, BEPA, BEPA-1MIX	68-92	26-57	1, 2

Table 7 continued

MRMEP	33.0-45.7	PICO, PICO-1MIX, PIPO, PIPO-1MIX, PSME, PSME-1MIX, IMXS, POTR5, POTR5-1MIX	34-71	27-59	1,2
SRMEP	22.9-38.1	PICO, PICO-1MIX, PIPO, PIPO-1MIX, IMXS, PSME, PSME-1MIX, POTR5, POTR5-1MIX	60-80	24-42	1, 2
Pfa					
Regional NRMEP MRMEP SRMEP	>=17.8	ABGR, ABGR-1MIX, ABLA, ABLA-1MIX, IMXS, LAOC, LAOC-1MIX, PIMO, PIMO3-1MIX, PICO, PICO-1MIX, PIPO, PIPO-1MIX, PSME, PSME-1MIX, TGCH, TSHE, TSHE-1MIX, THPL, THPL-1MIX, POTR5, POTR5-1MIX, BEPA, BEPA-1MIX	>= 50% for Regional, MRMEP, and SRMEP models; >=70% for the NRMEP model	24-59	1, 2
Foraging					
Regional		As above	>=40		1, 2
NRMEP		As above	>=40		1, 2
MRMEP		As above	>=40		1, 2

Table 7 continued			
SRMEP	As above	>=40	1, 2

[1] BA_WTD_DBH is the sum of the diameter of the tree times the number of trees the tree represents times basal area of the tree divided by total basal area.
[2] Subalpine fir (ABLA), Douglas-fir (PSME), ponderosa pine (PIPO), western white pine (PIMO3), western red cedar, (THPL), western hemlock (TSME), larch (LOAC), grand fir (ABGR), lodgepole pine (PICO), birch (BEPA), aspen (POTR5), tolerant grand fir, cedar, hemlock mix (TGCH), and no single dominant (IMIX). 1MIX refers to the dominance of one species within a sample. See Appendix 6 for detailed definitions.
[3] Basal area is the area of a cross section of a tree measured at diameter breast height and is a measure of density.
[4] Structure class: single story (1), two-story (2), three-story (3), and continuous (C), and none. See Appendix 6 for detailed definitions.
[5] North, Northeast, and Northwest aspect included in the model (see Table 8 and text).

11.3% was dominated by medium- or large-sized trees, and 65.7% by small-sized trees. On average, 68.9% of the pfa's contained forest with >50% canopy closure and 8.9% of the pfa's had 25% to 50% canopy closure.

Patla (1997) described the range of mature forest found in northern goshawk pfa's to be large (16 to 100%) and amount of young forest differed by dominant tree species, 15% in Douglas-fir to 3% in lodgepole forest. Overall, pfa's examined by Patla (1997) averaged 66.0 ± 4 % mature timber, 5.0 ± 2 % young trees, 18.0 ± 3 % seedlings, and 7.0 ± 2 % sagebrush.

Habitat Estimates

The wildlife habitat relationships nest site model (Table 7) used to estimate the amounts of northern goshawk habitat in the Northern Region by Ecological Province and Forest is based on five variables described in Table 5 (dominance group) and Table 6 (tree size, canopy cover, basal area, and number of canopy layers/structure). Where possible, the nest model is based on the use of the mean ± one standard deviation (thus should account for 68.3% of the estimated available habitat). Use of the mean plus or minus one standard deviation is common in the scientific literature to describe the variation associated with an environmental variable (Table 4) and provides a conservative estimate of habitat amount for the goshawk.

Two geographic levels of northern goshawk habitat relationship models are provided: a Region-wide model that reflects the full variance evident in habitat use by the northern goshawk, and second, an Ecological Province model that reflects the variation in habitat across the Northern Region.

As example in a Province-specific model adjustment is in the relationship of aspect to nest site. Table 8 summarizes nest location by aspect in the Northern Region. Northern goshawks selected nests in the NRMEP on northeast-north-northwest aspects (P = <0.01) with no apparent pattern in nest site selection by aspect in either the MRMEP or SRMEP. Aspect was included in the NRMEP wildlife habitat relationships model (Table 7) but not in either the MRMEP or SRMEP nest model.

Table 8. Number of goshawk nest locations on National Forest System lands by aspect and Ecological Province (Bailey 1996) in the USDA Forest Service Northern Region.

Aspect	NRMEP	MRMEP	SRMEP	Totals
North	31	10	0	41
Northeast	25	1	2	28
Northwest	29	8	1	38
South	11	8	0	19
Southeast	19	3	1	23
Southwest	11	4	1	16
East	9	12	1	22
West	8	11	1	20
Totals	143	57	7	207

The pfa habitat relationship model in this assessment for the northern goshawk (Table 7) is based on the recent scientific literature, both published and unpublished. The scientific literature for the goshawk pfa suggests: 1) a similarity in dominant species to that in nest sites (Patla 1997, McGrath et al. 2003, La Sorte et al. 2004); 2) less canopy closure and more younger trees in comparison to the nest site (Patla 1997, Clough 2000, McGrath et al. 2003); and 3) less structure and more difference in structure as distance increases from the nest site (Daw and Destefano 2001, McGrath et al. 2003).

The foraging habitat relationship model for the northern goshawk (Table 7) is based on the scientific literature. The northern goshawk forages in 1) a broad diversity of habitat types (Hargis et al. 1994), 2) areas with 40% or more forest canopy (Beier and Drennan 1997), 3) an open understory environment (Bloxton 2002) although understory may permit goshawks to approach prey unseen (Beier and Drennan 1997), and 4) a landscape representative of regional ecological conditions (Joy 2002, La Sorte 2004).

The size of an area that describes a northern goshawk nest site varies from 10 to 12 ha (Reynolds et al. 1992). Based on the appropriate Province nest site habitat relationship model, estimates of nest site habitat (Table 9) in the Northern Region range from 407 ha (or enough nest site habitat for about 7 to 33 pairs) on the Custer National Forest to 19,751 ha on the Beaverhead-Deerlodge National Forest (or enough nest site habitat for about 330 to 1646 pairs) (assuming one to five nests are constructed by the northern goshawk within the home range).

The size of an area that describes a northern goshawk pfa varies from 120 to 240 ha post-fledging area (Reynolds et al. 1992). Estimates of goshawk pfa habitat in the Northern Region range from a low of 13,167 ha (or enough pfa habitat for about 55 to 110 pairs) (Table 9) on the Flathead National Forest to 142,206 ha (or enough pfa habitat for about 592 to 1185 pairs) on the Beaverhead-Deerlodge National Forest.

Table 9. Summary of habitat estimates (ha) for the northern goshawk by National Forest in the USDA Forest Service Northern Region using the Northern Region northern goshawk habitat relationship models (Table 7) and FIA. The Ecological Province habitat estimates include only National Forest System lands.

		Model				
	Forest	Nest		Post fledging area		Foraging
		Regional	Province	Regional	Province	
Region		829,526	110,149	933,145	555,830	2,744,925
NRMEP		519,167	52,267	528,488	164,052	1,571,697
	Idaho Panhandle	137,420	16,201	145,225	58,132	381,193
	Kootenai	84,755	9,184	91,737	28,641	265,644
	Flathead	67,011	2,324	53,201	13,167	232,354
	Lolo	92,276	7,876	100,723	23,629	295,001
	Bitterroot	54,052	4,122	57,707	16,031	152,982
	Clearwater	83,653	10,939	79,895	24,452	244,523
MRMEP		276,711	53,290	364,257	364,088	1,004,478
	Beaverhead-Deerlodge	103,307	19,751	142,206	142,206	398,968
	Helena	36,475	8,843	47,925	47,754	127,638
	Lewis and Clark	52,739	7,876	67,642	67,346	196,426
	Nez Perce	84,190	16,780	106,484	106,782	281,446
SRMEP		33,648	4,592	40,400	54,652	168,750
	Gallatin	24,343	4,185	25,666	39,995	127,425
	Custer	9,305	407	14,734	14,657	41,325

Table 10. Historic (1938-43) and current estimates (%) of habitat (ponderosa pine, Douglas-fir, and larch large/saw timber) (Berglund 2005) important to the goshawk by Ecoregion (Bailey 1996) and National Forest in the USDA Forest Service Northern Region.

Province and National Forest	Cover type[1]	1938-42	Current
NRMEP			
Idaho Panhandle	PIPO	1.6	0.8
	PSME	1.4	11.9
	LAOC	3.7	7.8
Kootenai	PIPO	5.9	4.0
	PSME	0.3	13.3
	LOAC	11.2	12.4
Flathead	PIPO	1.5	0.6
	PSME	1.6	7.7
	LOAC	12.6	8.3
Lolo	PIPO	7.9	5.9
	PSME	0.9	15.1
	LOAC	7.1	8.6
Bitterroot	PIPO	8.9	7.2
	PSME	4.3	26.5
	LOAC	1.0	1.4
Clearwater	PIPO	2.1	1.0
	PSME	3.0	8.5
	LOAC	2.9	2.0
MRMEP			
Beaverhead-Deerlodge	PIPO	2.0	0.0
	PSME	2.1	9.5
	LOAC	0.4	0.0
Helena	PIPO	0.7	1.5
	PSME	4.6	11.6
	LOAC	1.0	0.0
Lewis and Clark	PIPO	0.7	0.8
	PSME	5.4	5.0
	LOAC	0.0	0.0
Nez Perce	PIPO	3.7	4.9
	PSME	5.6	7.9

Table 10 continued

[1] Ponderosa pine (PIPO), Douglas-fir (PSME), and larch (LOAC).

As noted before, estimates of northern goshawk home range size reported by different authors vary depending on age and sex of the bird, the habitat, and the methodology used in collecting and analyzing the data (Kennedy 2003). Neighboring pairs also may overlap in use of foraging areas but not in habitat used for a nest or pfa (Squires and Reynolds 1997).

Another component to northern goshawk habitat is to ensure it is well distributed habitat. The range in territory size for the northern goshawk is from 500 to 4,000 ha depending on age and sex of the bird, the habitat, and the methodology used in collecting and analyzing the data (Kennedy 2003).

These factors (variation in estimates, overlap in foraging area use by different pairs, and use of open habitats) make estimates difficult of the number of northern goshawk pairs that foraging habitat in the Northern Region can support. An estimate of foraging area based on non-overlapping pairs (1,758 ha based on telemetry, Bright-Smith and Mannan 1994) suggests a low in foraging habitat of the 41,325 ha (or enough foraging habitat for about 24 pairs) on the Custer National Forest to a high of 398,968 ha (or enough foraging habitat for about 227 pairs) on the Beaverhead-Deerlodge National Forest.

The estimated median dispersal distance (Bowman 2003) using the square root of a minimum territory size (500 ha) and multiplying by 12 for the northern goshawk is 268 km.

Appendix 7/Map 1 illustrates a 268 km buffer placed around the known goshawk nests in the Northern Region. The buffer shows young goshawks have the ability to interact with neighboring nests such that a single goshawk population exists in the Northern Region and habitat is well distributed by National Forest.

Table 10 provides a relative comparison of forest composition and structure as measured in 1938-1942 and that recently sampled by FIA. This comparison is limited to tree species most important to the northern goshawk for nesting (Table 5) and the structural category important to the goshawk (Table 6) and as measured in 1938-1942.

The comparison of the relative forest composition and structure in 1938-1942 to current in the composition and structural (large tree) characteristics important to the northern goshawk (Table 2 and 3) show a major trend (or increase) favorable to the goshawk (Table 10). These increases in amounts and sizes of Douglas-fir trees range from a modest increase on the Nez Perce National Forest (3.7% to 4.9%) to a substantial increase on the Lolo National Forest (0.9% to 15.1%). Only one Forest, the Lewis and Clark, exhibited a small decrease (saw timber 5.4% to 5.0%) in Douglas-fir habitat favorable to the goshawk.

Short-term Viability

No evidence exists that the northern goshawk is declining in numbers in the western United States (Kennedy 1997).

The four criteria to evaluate short-term viability are 1) distribution and amounts of habitat, 2) human disturbance, 3) biotic interactions, and 4) managing for ecological processes.

Distribution of habitat. Habitat for the goshawk is well distributed across the Northern Region and by Forest (Appendix 7/Map 1). This maps shows that utilizing 2/3 of the median dispersal distance, that effectively, there are not isolated populations of northern goshawk in the Region 1, rather one population exists in the forested portion of the Northern Region that interact.

Well distributed habitat for the northern goshawk in the Northern Region is not an issue—not a single nest site is isolated by more than 268 km to another nest.

Amounts of habitat. Northern goshawk habitat estimates (Table 9) in the Northern Region by Province for:

> 1) nest sites range from 407 ha (or enough nest site habitat for about 7 to 33 pairs) on the Custer National Forest to 19,751 ha on the Beaverhead-Deerlodge National Forest (or enough nest site habitat for about 330 to 1646 pairs) (assuming one to five nests are constructed by the northern goshawk within the home range).
>
> (2) pfa's from a low of 13,167 ha (or enough pfa habitat for about 55 to 101 pairs) (Table 9) on the Flathead National Forest to 142,206 (or enough pfa habitat for about 592 to 1185 pairs) on the Idaho Panhandle National Forests.
>
> 3) foraging area (non-overlapping) from a low in foraging habitat of the 41,325 ha (or enough foraging habitat for about 24 pairs) on the Custer National Forest to a high of 398,968 ha (or enough foraging habitat for about 227 pairs) on the Beaverhead-Deerlodge National Forest.

Habitat is abundant for the northern goshawk in the Northern Region and by Ecological Province and by National Forest.

Human disturbance. Moser and Garton (2004) found timber harvest had no effect on breeding area occupancy, nest success, or productivity 1 to 2 years after timber harvest. Occupancy of harvested breeding areas was 89% and 75% after 1 year and 2 year, respectively, compared to 80% and 78% of the pairs after 1 year and 2 year, respectively.

Penteriani and Faivre (2001) reported similar findings to Moser and Garton (2004). Their study in central Italy and eastern France (the northern goshawk is widely distributed in Europe) found no difference in the productivity of northern goshawk pairs reproducing in logged versus unlogged areas.

Penteriani and Faivre (2001) found that 87.5% of the northern goshawk pairs did move from logged stands only when the original nest stand structure was modified by more than 30%.

Penteriani and Faivre (2001) concluded northern goshawks could tolerate timber harvest as long as the cover reduction does not exceed 30% within the nest stand.

Penteriani and Faivre (2001) suggested in Europe for conservation that a buffer of 1 to 2 ha around a northern goshawk nest be established in areas managed by shelterwood systems and the distinctive habitat features around the nest should be protected in the 1 ha buffer. Forestry operations near a northern goshawk nest should be avoided according to Penteriani and Faivre (2001) from February to July (inclusive).

Northern goshawks in the Northwest of the United States are reported to select areas to nest near human activities (McGrath et al. 2003). Human disturbance is not a factor for the northern goshawk as long as 70% of the nest stand structure is maintained and timber management operations are time restricted.

Biotic interactions. The barred owl is on the increase in the western United States, to include in northern and central Idaho and northwest and north-central Montana (Accessed March 28, 2005; http://www.mbr-pwrc.usgs.gov/bbs) (1966-2003) at a rate that may exceed 1.5% per year in some areas. As with the spotted owl (Kelly et al. 2003), the barred owl represents a significant influence (predation on young) on northern goshawk abundance and distribution and therefore viability (Hanauska-Brown et al. 2003).

Virtually all of the current and highly modified and highly connected forested landscape in the Northern Region is potential barred owl habitat (Peterson and Robins 2003). Areas of particularly suitable habitat for the barred owl are in central Idaho and east central Montana.

A major and increasing threat to northern goshawk abundance and distribution is the barred owl.

Managing ecological processes. Fire and other ecological processes are important to maintain a continuing supply of mature trees, either an understory or open understory depending on need—pfa versus foraging and the heterogeneity required in foraging habitat.

Suppression of natural processes in the Northern Region has benefited the northern goshawk by: 1) increasing the distribution and abundance of forested habitats (Gallant et al. 2003, Hessburg and Agee 2003, Hessburg et al. 2004); 2) extensive and widespread encroachment by trees into open areas across the Northern Region (Coues 1893, Arno and Gruell 1986 and others); and 3) loss of grasslands in that many "historical surface fires in dry forests actually began on grassy benches, ridge tops, or valley bottoms adjacent to dry forests and woodlands, or in nearby shrub steppe communities, and then migrated into dry forests" (Hessburg et al. 2004: 5).

Short-term viability of the goshawk in the Northern Region is not an issue given the following.

- No scientific evidence exists that the northern goshawk is decreasing in numbers.
- Increases in the extent and connectivity of forested habitat have occurred since European settlement.

- Well-distributed and abundant northern goshawk habitat exists on today's landscape.

- Level of timber harvest (in 2004, 8581 ha of 9,045,255 ha or 0.0009%) of the forested landscape in the Northern Region) across is insignificant.

- Suppression of natural ecological processes has increased and continues to increase amounts of northern goshawk habitat.

The barred owl represents a significant threat to the northern goshawk in the short- and longterm.

5. Black-backed Woodpecker

Ecology, Behavior and Habitat

The black-backed woodpecker is strictly a North American species. Its breeding distribution extends across the boreal forests of Canada and Alaska into Newfoundland, dipping into the Midwest, and into the New England States (as cited in Dixon and Saab 2000 and Hoyt 2000). In the western United States, the range of the black-backed woodpecker extends south into central California and stretches east into Montana, Wyoming, and South Dakota (as cited in Dixon and Saab 2000 and Hoyt 2000).

The black-backed woodpecker during the breeding season is found in a diverse mixture of conifer species with no one species appearing to be essential (Dixon and Saab 2000). Although found in spruce dominated forests, the black-backed woodpecker is more often reported to be associated with pine, fir, and larch dominated forests (Boch and Boch 1974, Goggans 1986, Marshall 1992).

The black-backed woodpecker is a primary cavity nester in that they excavate their own cavities in April and May and most often in dead or dying conifer trees (Short 1974, Raphael and White 1984, Weinhagen 1998, Martin and Eadie 1999). Territory size around a nest cavity varies in size, e.g., 61 ha in Vermont, 72 ha in southwest Idaho, and 124 ha in Oregon (Dixon and Saab 2000). Young depart from the nest from early June through early July.

In winter, the black-backed woodpecker is considered to be sedentary (Dixon and Saab 2000). Irruptive movements, however, are well documented and demonstrate the bird's ability to travel long distances (Bangs 1900, Van Tyne 1926, West and Spiers 1959, Yunick 1985). Movements in winter are known as far south as Iowa, central Illinois, northern Indiana, and east into New Jersey (American Ornithologists' Union 1998).

Dixon and Saab (2000) in *The Birds of North America No. 298* provided detailed information on breeding range, non-breeding range, migration, morphology, pair formation, courtship and copulation, nesting phenology, metabolism and temperature regulation, molts and plumages, and demographics. Several internet websites provide further detailed information on the black-backed woodpecker (e.g., Accessed March 20, 2005; <http:/nhp.nris.state.mt.us/mbd>, and Accessed March 20, 2005; ttp://imn.isu.edu/digitalatlas>).

Understanding habitat requirements for the black-backed woodpecker in the northern Rocky Mountains and elsewhere is limited due to study design (Hoffman 1997). Few if any studies have equally sampled all habitats and seral stages in proportion to their availability on the landscape.

Studies to date of the black-backed woodpecker tend to focus on a single habitat type and therefore, suffer from "pseudoreplication" (Hoffman 1997). Pseudoreplication in a study refers to multiple sample sites within a single area or habitat type, therefore such sample sites are neither spatially nor temporally independent (Hurlbert 1984).

Ecologically sound habitat recommendations based on studies that differ in sampling design require a meta-analysis (Gurevitch et al. 2001) that is not available for the black-backed woodpecker. Winter habitat requirements and use by the black-backed woodpecker are virtually unknown.

Three possible causes exist to explain black-backed woodpecker distribution and abundance in the Northern Region: 1) use of post-burn areas; 2) use of insect outbreak areas; and 3) a pattern expected in a landscape with a natural range in the occurrences of natural processes such as fire and insect use. All three premises assume a close relation to the spatial and temporal distribution and abundance of bark beetles and or wood-boring beetles.

Both the black-backed woodpecker and the three-toed woodpecker, a closely related species (Short 1971), are described as opportunistic and respond to outbreaks of wood-boring beetles (Cerambycidae and Buprestidae) and bark beetles [mountain pine bark beetles (*Dendroctus* spp.)] in conifer forests following windfall or disease (West and Speirs 1959, Baldwin 1960, 1968, Wickman 1965, Koplin 1969, 1972, Crocket and Hansley 1978, Kroll and Fleet 1978, Bull 1980, 1983, Yunick 1985, Angelstam and Mikusinski 1994) as well as immediately following fire (Bourdo and Hesterburg 1951, Blackford 1955, Mayfield 1958, Heinselman 1973, Boch and Lynch 1970, Niemi 1978, Apfelbaum and Haney 1981, Taylor and Barmore 1980, Taylor 1979, Villard and Benninger 1993, Villard 1994, Hoffman 1997, Hejl and McFadzen 1998, Murphy and Lehnhausen 1998, Saab and Dudley 1998, Thompson et al. 1999, Setterington et al. 2000, Giroux and Savard 2003, and Nappi et al. 2003). Irruptive movements also appear to be opportunistic and exploit an abundance of wood-boring beetles or areas blighted with Dutch elm disease (Yunick 1985).

An example of a bark beetle is the western pine beetle which preferentially attacks old thick-barked ponderosa pine (McCullough et al. 1998). Sanchez-Martinez and Wagner (2002) recently compared *Dendroctus* spp. in ponderosa pine forests of northern Arizona to explore if the species assemblages and relative abundance differ between managed and unmanaged stands. Stand conditions included in the study were: 1) unmanaged stands with high tree density; 2) thinned stands; 3) thinned and burned (with prescribed fire) stands; and 4) stands that had been burned by stand replacing wildfires. Sanchez-Martinez and Wagner (2002) found population levels of all the bark beetle species were endemic across all stand conditions and timber management had little effect suggesting both a year-round beetle presence and availability (see also McHugh and Kolb 2003, McMillen and Allen 2003, Wallin et al. 2003).

In many other northern forest regions, outbreaks of *D. ponderosae, D. psuedotsuga and D. rufipennis* bark beetles have followed wildfire (Furnis 1965 and others). The response of at least one wood-boring beetle, the whitespotted sawyer beetle [also important to the black-backed woodpecker (Hoyt 2000)] is known to respond to the pheromones of bark beetles (i.e., *D. rufipennis*) (Groot and Knott 2004). Both charred and uncharred areas of conifers have been reported to be infested with species of *Monochamus* (McCullough et al. 1998).

Many Cerambycidae, such as *Monochamus* spp. (also black-backed woodpecker prey), are normally associated with trees that are injured, wind thrown, or damaged by ice and snow

(McCullough et al. 1998). They also may be attracted to recently burned areas and some wood-boring species, i.e., *Melanophila* spp., have infrared sensors on their legs which permit the detection of fire at distances of several kilometers.

The favorable effects of fire are not long lasting for either the bark beetle or the wood-boring beetle. Partially burned trunks and roots may provide habitat for the bark beetle for up to 10 years after burning (Werner 2002). The limiting factor for the Cerambycidae and Buprestidae is the moisture content of the wood. Insect development and survival decreases as trees dry out in four to eight years after fire depending on location (Werner and Post 1985). Population levels of both Cerambycidae and Buprestidae drop to levels below nearby undisturbed sites when post-fire areas change and dry over time. Partially burned areas near the perimeter of intensively burned sites provide habitat for diverse assemblages of wood-boring beetles.

Northern Region

Post-burn Areas

Lester (1980) examined the relationship of five woodpeckers and an endemic population of mountain pine beetles. Woodpeckers were observed to both feed and nest in post-fire areas. Harris (1982) in a study in a post-fire area near Missoula, Montana showed Picoides to be present although a decline occurred three years post-fire. This concentration of Picoides woodpeckers was in response to bark beetles and wood-boring beetle larvae in the fire-damaged trees. In this study, many lodgepole pines were attacked by mountain pine beetles but the short-term nature of the study precluded establishing consistent predictors of woodpecker densities.

In the summers of 1992-1994, Caton (1996) surveyed birds in the Red Bench post-fire area in northwestern Montana. Most of the burn area consisted of lodgepole previously killed by mountain pine beetles but included patches of Douglas-fir, Engelmann spruce, subalpine fir, western larch, ponderosa pine and other tree species. Additional transects in bordering 80-year old lodgepole pine but unburned stands were established for comparative purposes.

Caton (1996) found 11 black-backed nests in the post-fire area with cavities excavated in two tree species (Table 11). Caton (1996) did note (page 31) that large fires, i.e., the Red Bench in the study area, were not common historically in her study area and that fire suppression “may have serious consequences for the black-backed woodpecker” (page 31). Caton’s study showed that food availability and not nest site availability was limiting use of post-fire areas by both the black-backed woodpecker and the three-toed woodpecker.

Hutto (1995) estimated bird abundance in 34 burn sites in the northern Rocky Mountains following the 1988 forest fires (one fire in 1987). These data were compared to bird-count data in other vegetation types. Hutto (1995) found an abundance of black-backed woodpeckers and they seemed to be nearly restricted in distribution to post-burn habitats. Murphy and Lehnhausen (1998) expanded on Hutto’s observations, and suggested recently burned forests represented “source habitats,” i.e., population numbers may increase in post-fire and decrease when occupying other and unburned forests.

Table 11. Tree species used by the black-backed woodpecker for nest cavities in the western United States.

Nest tree	Oregon Bull et al. 1986	Montana Caton (1996)	Montana Hoffman (1997)	South Dakota Mohren (2002)	Montana Taylor and Schachtell (2002)
Douglas-fir		2	12		
Ponderosa pine	10			7	
Lodgepole pine	4				6
Western larch	1	9			

Table 12. Summary of key characteristics (mean) for trees black-backed woodpecker nest cavity trees in the Western United States.

	Oregon Bull et al. (1986)	Montana Caton (1996)	Montana Hoffman (1997)	South Dakota Mohren (2002)	Montana Taylor and Schachtell (2002)
Tree size dbh (cm)	37.0	40.0	27.0	24.89	>25.7
Tree height (m)	19.0	28.0	32.7	10.23	

Hoffman (1997) in 1995 and 1996 examined habitat use by the black-backed woodpecker, three-toed woodpecker and hairy woodpecker in the Greater Yellowstone Ecosystem. Hoffman (1997) found 12 black-backed woodpecker nests in ponderosa pine (Table 11) and in areas that were recently burned. Hoffman (1997) found no difference existed in the vegetation characteristics of black-blacked woodpecker nest sites and in random plots but high amounts of large down woody material did appear to be important. Hoffman (1997) interpreted the large amounts of down woody material to reflect remnants of the mountain pine beetle infestation of the Greater Yellowstone Ecosystem nearly two decades prior to her study.

Powell (2000) studied habitat use by the black-backed woodpecker in relation to prey density in two post-fire forests in the Selway-Bitterroot wilderness in eastern Idaho. Powell's (2000) study showed food availability is important, and, at least in recently burned forests, wood-boring beetles are an important food source. Moreover, "the most valuable habitat component may be wood-borers rather than a particular tree species, because no single tree species is consistently prey-rich" (page 88).

Mohren (2002) in the Black Hills of South Dakota during 2000 and 2001 found all black-backed woodpecker nest sites (n = 7) in ponderosa pine (Table 11). A direct discriminate analysis on significant habitat variables (nest tree diameter, nest tree height, and tree diameter) in a comparison to random sites was able to correctly classify 85.7% of the nest and random sites. Moorhen's (2002) study is unique in that variables were evaluated to detect autocorrelation.

Mohren (2002) evaluated a habitat relationships model for the black-backed woodpecker for lands managed by the Black Hills National Forest in South Dakota. The model included three habitat types (ponderosa pine, white spruce, and aspen) and three structural stages for ponderosa pine and two for white spruce. The model's effectiveness in predicting habitat was tested against black-backed woodpecker observations (n = 39). Habitat selection ratios based on black-backed woodpecker observations indicated black-backed woodpeckers avoid areas with less than 70% canopy with some selection for sapling pole stages with any canopy cover.

Mohren (2002) found the black-backed woodpecker foraged in habitats with certain characteristics, i.e., bare ground (mean = 84.4, p = 0.041), greater percentage of canopy (mean = 68.9%, P = 0.037), smaller trees (mean = 24.1, P = 0.015), higher snag basal areas (mean = 3.52, P = 0.002), higher snag densities (mean = 4.7/0.04 ha, P = 0.021), lower snags in terms of height (mean = 5.03, P = 0.013), and in ponderosa pine (>70% cover, P = 0.001).

Insect Outbreaks

Hughes (2000) in northeastern California studied snag decay and black-backed woodpecker foraging in four 150 ha areas in northeastern from June through October 1999. Like Bull et al. (1986), Hughes (2000) found the black-backed woodpecker used trees experimentally infested with bark beetles, and in a pattern similar to Bull et al. (1986), preferred snags (82% of observations, P = <0.001). Use of snags began within one year of bark beetle infestation. Areas considered being important for meeting black-backed woodpecker foraging requirements included sick, injured, and declining trees in addition to recently dead trees killed by mountain pine beetles.

Mohren (2002: 87) in his study of the black-backed woodpecker in the Black Hills of South Dakota concluded "It is also possible these woodpecker species are not selecting foraging location based on habitat characteristics, but are selecting areas populated with wood-boring beetles." Mohren (2002) criticized management recommendations in the Black Hills Forest plan (1996 Revised Land Resource Management Plan Final Environmental Statement III-450) that call for thinning in that such timber management would reduce habitat suitable for insect outbreaks and, therefore, habitat for the black-backed woodpecker.

Mohren (2000: 86, 87) further suggested a need to create "stands that will become susceptible to wood-boring beetles will provide an abundance of prey for both of these species (black-backed and three-toed woodpeckers) as part of forest management by the Black Hills National Forest. Also, allowing large areas to become infested with wood-boring beetles (such as Baer Mountain area) is suggested to let black-backed and three-toed woodpeckers increase in population size. Current outbreaks should be examined to determine the effects wood-boring beetles have on black-backed and three-toed woodpecker."

Winter/Natural Distribution

Fayt (2003) in a study of the closely related three-toed woodpecker suggests: 1) the need to study woodpecker ecology on both the local and larger scales; 2) three-toed breeding population is limited by food availability outside of the breeding season (see also Perrins 1966, Nilsson 1987, Newton 1998, and others); 3) oldgrowth habitats with a continuous production of heterogeneity in forest structure (i.e., regular gap dynamics that create a mosaic of types) allow for stable woodpecker populations (versus the boom/bust pattern associated with post-fire habitats); 4) breeding density was influence by bark beetle abundances while variation in brood size was influenced by the abundance of wood-boring beetles; and 5) regional networks of older forest with natural gap dynamics were most important to long-term conservation of the species and the control/prevention of large outbreaks of bark beetles by woodpecker predation.

Mohren (2002) suggested that historically small but widespread outbreaks of wood-boring beetles in a natural landscape could have supported the black-backed woodpecker. R. Dixon (2005, personal communication, Idaho Fish and Game, Boise) also suggests the black-backed woodpecker may be neither dependent on either post-fire or insect outbreaks but may be well distributed but relatively uncommon in the more natural landscape.

As noted by Hoyt and Hannon (2002), few studies have considered all habitats in proportion to availability nor considered the comparative difficulty in observing birds in open post-fire habitats versus the more closed and structurally complex live forest environment.

Hoyt and Hannon (2002) found black-backed woodpeckers in stands of old spruce 75 to 150 km distant from the post-fire study, suggesting an ability for the black-backed woodpecker to survive in non-post fire areas. Hoyt (2000: 34) further notes "to assess the source-sink dynamics of recently burned and oldgrowth black spruce habitats estimates of fecundity and survival would be required." Hoyt's sample size (n = 22 nests) was inadequate to estimate either fecundity or survival rates to estimate source-sink dynamics. Hoyt (2000: 34) continued with "I believe that with an intensified search effort it would be possible to find nests in unburned forests (see Weinhagen 1998). Therefore, I believe that oldgrowth black spruce sites embedded in a matrix of old forests need to be examined more closely before they can be classified as sink habitat."

Tree mortality due to the mountain pine beetle can occur as scattered individual trees well distributed across the landscape or may impact entire groups of trees. Such outbreaks by the

Table 13. Summary of the number of fires near six black-backed woodpecker nests and relative percent of forest vegetation and structure within a 3.2 km circle centered on the nests on the Idaho Panhandle National Forests (Taylor and Schachtell 2002). Median fire size is 1.1 ha.

	Nests					
	Saddle Creek	Murray Creek	Cuban Hill	Mission Creek	Camp Nine	Moyie Creek
Number of fires near a nest	7	2	5	2	1	4
Tree species						
Cedar	14	28		14		10
Douglas-fir	2		7	16		
Grand fir		4	2	2	27	9
Larch	9	1	2	12	17	8
Lodgepole pine	9	2	3	10		9
Subalpine fir	52	2		8	1	1
Ponderosa pine		1		8	19	1
Western hemlock	8	8		6	8	
White pine	4		3	5	8	
Non-forest		6			4	
Birch					4	4
No data	3	48	77	11	12	58
Structure						
Multiple sizes	2	5	1	3		7
Pole	2	12	11	34	39	7
Saw timber	76	26	4	31	31	24
Young or non-forest	21	6	9	26	18	6
No data		53	77	6	12	58

mountain pine beetle are known to have occurred historically and may last 8 to 11 years (Amman and Code 1983). Wood-boring beetles historically have always been abundant in small pockets, and large outbreaks can occur approximate every 11 years and can last for more than a decade (Mohren 2002).

An example of the "natural" landscape may be on the Idaho Panhandle National Forests in northern Idaho (Table 13). Taylor and Schachtell (2002) examined the habitat in a 3.2 km circle surrounding six black-backed nests. Two nests were in larch and four in lodgepole pine and all were in trees > 25.7 cm, similar to nest tree size reported in other studies (Table 12).

Taylor and Schachtell (2002) related a Forest Service Oracle database that describes stand characteristics to GIS to conduct the analyses. Analyses by Taylor and Schachtell (2002) showed a great degree of heterogeneity in habitat and structure classes surrounding the six nest sites (Table 13).

No specific pattern in habitat selection was evident in the Taylor and Schachtell (2002) analyses other than size of tree selected for a nest cavity (see Table 13). All black-backed woodpecker nests were in trees > 25.7 cm and similar to nest tree size reported in other studies. A first query of the US Forest Service database FSVEG showed 68.2% of the 1506 sample points on the Idaho Panhandle National Forests had trees of sufficient size (> 25.7 cm) to be a nest cavity tree for the black-backed woodpecker. Fire has impacted 8 and harvest 36 of the 1550 total sample points but the exact location is not known and are removed from the estimate.

Taylor and Schachtell (2002) analyzed the number of snags (averaged dbh as small as 2.4 cm per stand) in a circle (926 m radius) around each of the black-backed nest sites and additional black-backed observations (total n = 16) using the Timber Management Reporting System. Taylor and Schachtell (2002) found a mean for number of snags (>= 2.4 cm) around either a nest or individual observation to be 143.8 ± 77.3. The mean of 143.8 reported by Taylor and Schachtell (2002) is less than that reported by Bull et al. (1986: Table 2, 180.0 ± 180.9) in Oregon but no significant differences would exist given the overlap in standard deviations.

A second query (using the mean ± one standard deviation or 66.5 to 221.1 cm and less than five years since their death, the period assumed to be favorable to wood-boring beetles) of the US Forest Service database FSVEG shows number of snags suitable for black-backed foraging to be present on 30.6% of the 1506 sample points on the Idaho Panhandle National Forests. Fire has impacted 8 and harvest 36 of the 1550 total sample points but the exact location is not known and are removed from the estimate.

Sightings of black-backed woodpecker (Taylor and Schachtell 2002) on the Idaho Panhandle National Forest follow a similar pattern in use of many habitats, i.e., in recently burned stands (8), unburned stands (49), burn status unknown but not evident (27), logged stands (15), unlogged stands (23), or logging history unknown (46). No association with either large post-fire areas or large insect infested areas was evident in the sightings information.

Within forested ecosystems, gap dynamics—the influence of insects, lightning strikes, ice, disease and other factors—create a mosaic of structure and age classes at the stand level and attract bark and other beetles (Hayes and Daterman 2001). Saproxylic beetles (Hammond et al. 2004), Douglas-fir beetle (McMillan and Allen (2003), and bark beetles (Hayes and Daterman

2001) are known to influence stand structure. Areas affected by outbreaks of bark beetles may not be followed by fire (Bebi et al. 2003). Such areas provide an insect rich but fire-free environment and a natural mosaic of beetle distributions.

Habitat in the Northern Region

Hoffman (1997) suggests a viability strategy for the black-backed woodpecker should be regional in scale. Both disease and fire as ecological processes important to the black-backed woodpecker often operate at relative large scale both in time and space due to factors such as climate (Schoennagel et al. 2004).

The black-backed woodpecker is somewhat unusual in that it is not thought to be a migrant (Dixon and Saab 2000) but also is known to make “irruptive” movements most often in winter (Yunick 1985). The reasons for such irruptive movements by the black-backed woodpecker are speculative. In general, climate and food resources interact to influence the spatial synchrony in movements among different bird species (Jones et al. 2003) and well-known irruptive species [i.e., the genus Carduelis (crossbills, bull finches, etc.)] tend to move in large flocks (Newton 1998). Such characteristics (timing of movement shared among species, large flock size and so on) are not shared by the black-backed woodpecker.

The black-backed woodpecker is found in post-fire areas [up to 8 years following fire (Hoyt and Hannon 2002)] and in areas of insect damage (Bull et al. 1986). Table 14 provides an estimate of the area impacted by fire or by insects in two time intervals, 1990-1993 and 2000-2003.

The 2000-2003 time interval was selected to represent the most recent available information. The seven-year time interval was selected to ensure the 1990-1993 areas either impacted by fire or insects were no longer suitable for the black-backed woodpecker. Only Hoyt and Hannon (2002) note that a post-fire area may remain suitable for the black-backed woodpecker up to an interval of 8 years post-fire. Most authors suggest around five years is the time interval when impacted habitats remain suitable to the black-backed woodpecker (thus the four year interval is very conservative in this assessment as a base to estimate habitat amounts for the black-backed woodpecker).

The size of an area that describes a black-backed woodpecker territory varies from 72 ha to 124 ha (as cited in Dixon and Saab 2000 and in Hoyt 2000). Estimates of black-backed woodpecker habitat in burn areas in 1990-1993 ranges from 0 ha (on five National Forests) to 8,724 ha [Nez Perce National Forest (Table 14) or post-fire habitat for 70 to 121 pairs].

Estimates of black-backed woodpecker habitat in burn areas in 2000-2003 ranges from 2,329 ha (Idaho Panhandle National Forests) to 145,409 ha (Bitterroot National Forest) (Table 14) (or providing habitat for upwards to 18 to 31 pairs on the Idaho Panhandle National Forests in post-fire areas to upwards to 1,172 to 2,019 pairs on the Bitterroot National Forest).

Estimates of black-backed woodpecker habitat in insect-infested areas in 1990-1993 ranges from 389 ha (Helena National Forest) to 72,882 ha (Kootenai National Forest) (Table 14) (or

Table 14. Summary of black-backed woodpecker post-fire and insect-infested habitat (ha) estimates by National Forest in the USDA Forest Service Northern Region during 1990-1993 and 2000-2003.

National Forest	1990-1993		2000-2003	
	Fire[1]	Insect[2]	Fire	Insect
NRMEP				
Idaho Panhandle		4,014	2,239	123,067
Kootenai	6,237	72,582	17,362	18,390
Flathead	24.7	7,582	78,803	23,259
Lolo		8,738	55,608	70,273
Bitterroot	3,833	2,508	145,409	17,701
Clearwater	1,714	864	18,021	8,131
MRMEP				
Beaverhead-Deerlodge		19,636	24,406	46,045
Helena		387	38,627	4,044
Lewis & Clark	2,042	1,119	8,231	6,223
Nez Perce	8,724	6,479	27,767	125,016
SRMEP				
Custer		884	29,220	2,329
Gallatin	4436	32,615	15,471	15,667

[1] Estimates of fire perimeters are available from the Cohesive Fire Project, US Forest Service (http://www.fs.fed.us/r1/firegis/2003web/atozdata.htm).
[2] Insect out break estimates are based on annual surveys conducted by the US Forest Service (ftp://.r1.fs.fed.us/pub/ads/appendall).

providing habitat for 3 to 5 pairs on the Helena National Forest in insect-infested areas to about 585 to 1,008 pairs on the Kootenai National Forest).

Estimates of black-backed woodpecker habitat in insect-infested areas in 2000-2003 range from 9,992 ha (Helena National Forest) to 304,099 ha (Idaho Panhandle National Forests) (Table 14) (or providing habitat for 80 to 139 pairs on the Helena National Forest in insect-infested areas to about 2,452 to 4,224 pairs on the Idaho Panhandle National Forest).

How many black-backed woodpeckers bred in either the post-fire or the insect-infected areas during the intervals from 1990-1993 or 2000-2003 is unknown. It is very unlikely that the black-backed woodpecker reached the potential densities as estimated above. This would require a (boom or bust) population growth rate characteristic to a microbe.

Clearly evident is a consistent and often *substantial* increase in the amounts (e.g., from 278% on the Kootenai National Forest to over 300,000% on the Flathead National Forest) of post-fire habitat on all 12 National Forests in the Northern Region (Table 14). Only two National Forests, the Gallatin and Kootenai, show a decrease in the amount of insect-infested habitat. The remaining 10 National Forests show substantial increases (e.g., from 4,014ha to 123,067 ha on the Idaho Panhandle) in amounts of insect-infested habitat.

A second consideration is to provide well-distributed habitat. Territory size around a nest cavity for the black-backed woodpecker varies, e.g., 61 ha in Vermont, 72 ha in southwest Idaho, and 124 ha in Oregon (Dixon and Saab 2000) reflecting either differences in habitat or in methodology or other factor.

Appendix 8/Map 2 illustrates a 102 km buffer [square root of the 72 ha home range recorded in Idaho times 12, Bowman (2003)] placed around each burn area and insect infested area in the Northern Region. This estimate (102 km) of dispersal distance is also substantially less than the distances traveled in the irruptive movements by the black-backed woodpecker reported by Yunick (1985).

Habitat for the black-backed woodpecker if dependent upon either post-fire- or insect infested areas is well distributed across the Region and by Forest (Appendix 8/Map 2). Distances between neighboring post-fire or insect infested areas are all within 102 km.

Fayt (2003) in a study of the three-toed woodpecker suggests its (a species closely related to the black-backed woodpecker) breeding population is limited by food availability outside of the breeding season and that oldgrowth habitats with a continuous production of heterogeneity in forest structure (i.e., regular gap dynamics that create a mosaic of types) allow for stable woodpecker populations.

Fayt (2003) further suggests that regional networks of older forest with natural gap dynamics are both important (the key factor in population persistence) to the long-term conservation of the species and to the control/prevention of large outbreaks of bark beetles.

Virtually nothing is known of the habitats requirements for the black-backed woodpecker in winter other than in the most general terms, e.g., sedentary (Dixon and Saab 2000) and irruptive (Yunick 1985). It is possible that two closely related species—the black-backed woodpecker and three-toed woodpecker—may share strategies important to year-round survival, i.e., use of a forest where natural gap dynamics (lightning strikes, ice/snow damage, insect damage, wind-throw, and so on) provide the heterogeneity required for long-term persistence. It is not possible to inventory or map such habitats.

Short-term Viability

Evidence suggests the black-backed woodpecker is increasing in numbers in the United States (as cited in Dixon and Saab 2000).

The four criteria to evaluate viability are 1) distribution and amounts, 2) human disturbance, 3) biotic interactions, and 4) managing for ecological processes.

Distribution of habitat. Placing a 102 km buffer around either burn areas or areas of high insect infestation shows no gap between current burn- or insect infested areas that would limit black-backed woodpeckers from interacting (Appendix 8/Map 2).

Habitat for the black-backed woodpecker is well distributed across the Northern Region and by Forest.

Amounts of habitat. Habitat is abundant for the black-backed woodpecker (Table 14).

Clearly evident is a consistent and substantial increase in the amounts (e.g., from 278% on the Kootenai National Forest to over 300,000% on the Flathead National Forest) of post-fire habitat on all 12 National Forests in the Northern Region (Table 14). Only two National Forests, the Gallatin and Kootenai, show a decrease in the amount of insect-infested habitat. The remaining 10 National Forests show substantial increases (e.g., from 4,014 ha to 123,067 ha on the Idaho Panhandle) in amounts of insect-infested habitat.

Human disturbance. Timber management is a factor suggested to affect the black-backed woodpecker, particularly in post fire areas or sites with high insect infestation.

Timber management (seed shelterwood, selection, salvage, and intermediate) in the Northern Region in 2004 amounted in total to 8,581 ha of 9,045,255 forested ha in the Northern Region or 0.0009% of the landscape. Level of timber management in preceding years was 10,542 ha in 2003, 8516 ha in 2002, 5283 ha in 2001 and so on. Salvage timber management in 2004 was 1210 ha or 0.0005% of the area affected by fire or insects (Table 14) (see also Gallant et al. 2003 whom concluded timber management in the GYE is not an issue compared to other landscape changes).

Biotic interactions. None known.

Managing ecological processes. Habitat for the black-backed woodpecker has recently increased (Table 14), and amounts today are expected to increase as fires and insects outbreaks continue to increase in size and in a pattern distinctly different from that evident historically (Zack 1997, Gallant 2003, Hessburg and Agee 2003, Hessburg et al. 2004 and others).

Short-term viability of the black-backed woodpecker in the Northern Region is not an issue given the following.

- No scientific evidence exists that the black-backed woodpecker is decreasing in numbers.

• Increases in the extent and connectivity of forested habitat since European settlement.

• Increases in amounts of small and mid sized trees have increased since European settlement.
• Well-distributed and abundant black-backed woodpecker habitat exists on today's landscape.
• Level of salvage timber harvest (in 2004, 1210 ha of 2,276,588 ha or 0.0005%) or overall timber harvest (8581 ha of 9,045,255 or 0.0009% of the forested landscape in the Northern Region) is insignificant.

6. Flammulated Owl

Ecology, Behavior and Habitat

The flammulated owl "is perhaps the most common raptor of the montane forests of the western United States" (McCallum 1994a:1). The breeding range of the flammulated owl extends south from southern British Columbia (Christie and Woudenberg 1997) into California (Small 1994), Idaho (Groves et al. 1997), Nevada (Dunham et al. 1996), western Wyoming (Oakleaf et al. 1992), Colorado (Reynolds and Linkhart 1987), Arizona (Balda et al. 1975), New Mexico (McCallum 1994b), and well into Mexico (American Ornithologists' Union 1998).

The female flammulated owl selects the nest site that is most often an old pileated woodpecker or northern flicker nest cavity (McCallum 1994a). The nest cavity is used year after year by the flammulated owl pair. Linkhart et al. (1998) reported a mean size territory (four males equipped with radio transmitters) of 11.1 ± 1.9 ha in 1982 and 18.3 ± 5.1 ha in 1983.

One to four areas (0.5 ± 0.4 ha in size) near the nest cavity are important foraging areas to the flammulated owl (Linkhart et al. 1998). The flammulated owl subsists nearly exclusively on insects, especially moths and beetles, and forages in the tree canopy, between trees, and on the ground.

Young flammulated owls remain within 100 m of the nest site for a week after leaving the nest cavity (McCallum 1994a). Young flammulated owls gain independence from the parents in foraging for prey in about 25 to 32 days.

Flammulated owls leave their breeding areas beginning in August and over-winter in middle America and return to breeding areas in late April and early May (McCallum 1994b). About 50% of the flammulated owls return to the same area with males showing either a higher fidelity to nest area and or survival rate.

McCallum (1994a) summarized the studies of McCallum and Gehlbach (1988) and Goggans (1986) (Table 15). In general, flammulated owls nested in relatively large trees in relatively open areas. McCallum and Gehlbach (1988) report owls selected areas with the most abundant pool of woodpecker cavities and neither McCallum and Gehlbach (1988) nor Goggans (1986) demonstrated differences in occupied and unoccupied habitat.

Bull et al. (1990) described 33 flammulated owl nests (Table 15) in northeastern Oregon during 1987-1988. Large diameter trees (average = 72 cm) with flicker cavities were used for nesting. Nest trees were located on ridges and upper slopes with east or south aspects and in stands of ponderosa pine and Douglas-fir or grand fir with ponderosa pine in the overstory (see also Bull and Anderson 1978).

In Colorado, Reynolds and Linkhart (1992) (Table 15) reported nearly all nest records at that time for the flammulated owl were located either in ponderosa pine or Jeffrey pine. Linkhart (2001) (Table 15) summarized a study extending nearly two decades on habitat use and demographics of the flammulated owl. As in earlier studies (Reynolds and Linkhart 1987,

Table 15. Summary of key characteristics (mean ± SD unless noted, sample size in parentheses) of flammulated owl habitat reported in studies conducted in areas other than the USDA Forest Service Northern Region.

	Oregon Goggans (1986)	New Mexico McCallum and Gehlbach (1988)	Oregon Bull et al. (1990)	Colorado Linkhart (2001)
Nest				
Tree size (dbh, cm)	53.3 ± 11.9 (20)	46.2 ± 10.7 (17)	72.0 ± 14.4 (33)	33.0 ± 42.2 (14)
Tree height (m)	26.6 ±12.0 (20)	10.6 ± 3.9 (17)	24.0 ± 0.1 (33)	
Habitat				
Tree density/ha	589 ± 451 (20)	504 ± 416 (17)	330 ± 146 (33)	
Tree size (bdh, cm)			35.0 ± 2.5 (33)	
Shrub density		442 ± 619 (17)	40.0 ± 296 (33)	
Canopy closure			55.0 ± 20.1 (33)	

1992), flammulated owls preferred open areas of ponderosa pine or ponderosa pine/Douglas-fir (Table 18). Howie and Ritcey (1987) in British Columbia reported use of Douglas-fir stands as nest sites.

The flammulated owl is also known to nest in Jeffery pine stands mixed with fir, quaking aspen, cottonwood (Marshall 1939, Johnson and Russell 1962, McCallum 1994a) and white oak (Bent 1938). In northern Utah, nest boxes placed in nearly pure and open stands of aspen were quickly used by the flammulated owl (Marti 1997).

Linkhart (2001) emphasizes the importance of distinguishing singing mates versus males with mates. Bachelor (and singing) males occupied 70% of territories in the non-preferred habitat, i.e., in areas with more and younger Douglas-fir habitat. McCallum (1994a: 23) echoed the importance to distinguish breeding/often silent versus non-breeding/singing males in the development of conservation strategies for the flammulated owl.

Linkhart (2001) reported that density of cavity trees is not related to reproduction but fundamentally important to territory establishment by male flammulated owls. Linkhart suggested no strong evidence exists that flammulated owls nest in colonies as suggested by Winter (1974). Rather, flammulated owls aggregate around clusters of nest cavities.

Linkhart (2001) concluded the association of flammulated owl productivity with higher densities of larger diameter trees suggests that flammulated owls are adapted to forests that were historically maintained by fire. Fire suppression in many western forests, which were historically characterized by open stands of large-diameter trees prior to European settlement, has resulted in higher tree densities especially in the smaller diameter classes. Fire suppression has resulted in conversion of many pine forests to shade-tolerant fir forests and high tree densities in smaller diameter classes. Overall "fire suppression may be resulting in suboptimal habitat for flammulated owls" (page 168).

In Oregon, home ranges exhibited by the flammulated owl were smaller (10.3 ± 6.3 ha) (Goggans 1986) then those reported by Linkhart (2001). Goggans (1986) suggested the more broken canopy with more openings may have resulted in higher levels of prey availability. Understanding foraging behavior and prey diversity in flammulated owl diets is difficult due to their foraging at night or in late evening/early morning. Goggans (1986) recorded that home ranges were on upper slopes and plateaus with ponderosa pine and Douglas-fir the dominant tree cover.

McCallum and Gehlbach (1988) (Table 15) found flammulated owls in New Mexico preferred open, mature vegetation for nest sites. McCallum and Gehlbach (1988) further noted that flammulated owls may choose sites with low shrub cover in front of a nest such that an open flight path is available. McCallum and Gerhard (1988) as well as Goggans (1986) described a need for roost sites, particularly important just before fledging, and distances from the nest site to roost sites may vary and decrease (<100 to <20m) just prior to fledging.

A study in Canada (Howie and Ritcey 1987) is important for it suggested that structure and floristics are important to the flammulated owl in selecting breeding territories. Flammulated owls in British Columbia selected areas with modest canopy (35 to 65%, an ocular estimate) in areas with mature forest (140 to 200 years) and with two canopy layers.

More detailed information for the flammulated owl for the breeding range, non-breeding range, migration, morphology, pair formation, courtship and copulation, nesting phenology, metabolism and temperature regulation, molts and plumages, and demographics are found in *The Birds of North America No. 93* (McCalllum 1994a) and in Hayward and Verner (1994). Several internet

Table 16. Summary of key characteristics (mean ± SD unless noted, sample size in parentheses) of flammulated owl habitat in studies conducted in Idaho and Montana and within the Northern Region. Mean values are provided for Groves et al. (1997). Number of flammulated owl nests is included in parentheses.

	Montana Wright (1996)	Idaho Groves et al. (1997)
Nest		
Tree size (dbh) (cm)		31 (27)
Surrounding habitat		
Tree density/ha		494 (27)
Tree size (bdh) (cm)	>23 cm	31 (27)
Shrub density (%)	Meadow/mesic 3.95 ± 3.74, grassland/xeric 17.92 ± 12.51	21 (27)
Canopy closure (%)	Ponderosa pine <40 to <70 in ponderosa pine/Douglas-fir	52 (27)

websites provide further detailed information on the flammulated owl (e.g., Accessed March 20, 2005; <http:/nhp.nris.state.mt.us/mbd>, and Accessed March 20, 2005; <http://imn.isu.edu/digitalatlas>).

Northern Region

Wright (1996) established three study areas that were largely managed by the Bitterroot National Forest but with portions in the Lolo National Forest and Deerlodge National Forest. Wright (1996) conducted surveys at points along 67 transects 480 m in length place near Forest Service secondary roads. Adjustments were made to the survey procedure in year 2 to account for unoccupied areas.

Calling flammulated owls in Wright's study (1996) were correlated with number of ponderosa pine trees >38 cm (P = 0.043) and live basal area (P = 0.001) (Table 16). On a landscape level,

Table 17. Regional and Ecological Province habitat relationships model for the flammulated owl in the USDA Forest Service Northern Region.

Model	Dominance group[1]	Canopy coverage (%)	Aspect[2]	Structure class[3]	BA-WT_DBH[4] (cm)	Snag
Regional NRMEP MRMEP	PIPO, PIPO-1MIX; PSME, PSME-1MIX	35 to 85	SE, S, SW, W, LR for PSME and PSME-1MIX	1 or 2	>=30.5 cm for the Region and MRMEP, >= 35.5 for the NRMEP	>=1/ha, >= 25cm

[1] Douglas-fir (PSME); and ponderosa pine (PIPO); and no single dominant (IMIX). See Appendix 6 for detailed definitions.
[2] Southeast (SE), South (S), Southwest (SW), West (W), and level rolling (LR).
[3] Structure class: single story (1), and two-story (2). See Appendix 6 for detailed definitions.
[4] BA_WTD_DBH is the sum of the diameter of the tree times the number of trees the tree represents times basal area of the tree divided by total basal area.

calling flammulated owls were associated with low canopy (<40%) in ponderosa pine (P = 0.0091) and moderate canopy (<70%) in ponderosa pine/Douglas-fir (P = .0237).

Habitat analysis by Groves et al. (1997:120) on the Nez Perce National Forest in central Idaho showed flammulated owls used “stands with mature to old ponderosa pine and Douglas-fir, multiple canopy layers, low tree densities, moderate to low canopy closure, and moderate ground cover” (Table 16). Groves et al. (1997) concluded that “fire suppression and timber harvest” may threaten the long-term persistence of the flammulated owl.

Modeling to predict habitat for the flammulated owl at the broad-scale in British Columbia Canada by Christie and Woudenberg (1997) used two variables: 1) percent cover (55 to 100% for Douglas-fir and 3 to 45% for lodgepole pine); and 2) age class categories.

The Northern Region flammulated owl (Table 17) wildlife habitat relationships model is based on variables reported by Wright (1996) and Groves et al. (1997): 1) dominance groups to describe the vegetation composition; 2) range in canopy cover; 3) structure class (number of vegetation layers); 4) basal area to reflect size of tree; and 5) a snag. Tree size is modeled by > = mean minus one standard deviation with the assumption no upper limit exists in size of tree used by the flammulated owl.

Table 18. Summary of habitat estimates (ha) for the flammulated owl by National Forest in the USDA Forest Service Northern Region using the Northern Region flammulated owl habitat relationship models (Table 17) and FIA.

Ecological Province	Forest	Habitat
NRMEP		39,253
	Idaho Panhandle	13,342
	Kootenai	4,296
	Flathead	2,324
	Lolo	6,444
	Bitterroot	6,412
	Clearwater	6,435
MRMEP		21,235
	Beaverhead-Deerlodge	1,975
	Helena	3,243
	Nez Perce	16,017
SRMEP		5,841
	Gallatin	5,581

Two geographic levels of flammulated owl habitat relationship models are provided: a Region-wide model that reflects the full variance evident in habitat use by the flammulated owl, and second, an Ecological Province model that reflects the variation in habitat across the Northern Region (Table 17).

At the Region-wide and Ecological Province, habitat for the flammulated owl is abundant and widespread in the Northern Region (Table 18). Linkhart (2001) reports a mean size territory (four males equipped with radio transmitters) of 11.1 ± 1.9 ha in 1982 and 18.3 ± 5.1 ha in 1983.

Table 19. Historic (1938-43) and current estimates of habitat (percent of Forest) important to the flammulated owl by Ecoregion (Bailey 1996) and by National Forest in the USDA Forest Service Northern Region. See Berglund (2005) for details on historic estimates of habitat.

Ecological Province/ National Forest	Cover type1	Size class[2]	1938-42 (%)	Current (%)
NRMEP				
Idaho Panhandle	PIPO	Saw	1.6	0.8
		Pole	1.4	0.5
		Seedling/sapling	0.6	0.0
	PSME	Saw	1.4	11.9
		Pole	2.0	2.8
		Seedling/sapling	0.6	2.0
Kootenai	PIPO	Saw	5.9	4.0
		Pole	2.1	0.3
		Seedling/sapling	1.3	0.3
	PSME	Saw	0.3	13.3
		Pole	1.0	8.9
		Seedling/sapling	0.2	3.8
Flathead	PIPO	Saw	1.5	0.6
		Pole	0.5	0.3
		Seedling/sapling	0.2	0.0
	PSME	Saw	1.6	7.7
		Pole	1.2	8.9
		Seedling/sapling	0.2	5.0
Lolo	PIPO	Saw	7.9	5.9
		Pole	3.4	0.9
		Seedling/sapling	3.1	1.2
	PSME	Saw	0.9	15.1
		Pole	3.4	15.4
		Seedling/sapling		
Bitterroot	PIPO	Saw	8.9	1.2
		Pole	0.8	0.5
		Seedling/sapling	0.9	0.5
	PSME	Saw	4.3	26.5
Clearwater	PIPO	Saw	2.1	1.0
		Pole	0.4	0.0
		Seedling/sapling	0.3	0.0
	PSME	Saw	3.0	8.5
		Pole	2.0	3.7
		Seedling/sapling	1.2	1.7

Table 19 continued

MRMEP				
Beaverhead-Deerlodge	PIPO	Saw	2.0	0.0
		Pole	0.3	0.0
		Seedling/sapling	0.1	0.0
	PSME	Saw	2.1	9.5
		Pole	13.5	14.7
		Seedling/sapling	0.9	1.4
Helena	PIPO	Saw	0.7	1.5
		Pole	0.1	1.5
		Seedling/sapling	0.0	0.0
	PSME	Saw	4.6	11.6
		Pole	7.7	28.3
		Seedling/sapling	0.5	5.1
Nez Perce	PIPO	Saw	3.7	4.9
		Pole	0.7	0.3
	PSME	Saw	5.6	7.9
		Pole	3.8	4.9
		Seedling/sapling	2.2	4.6

[1] Douglas-fir (PSME), ponderosa pine (PIPO); and no single dominant (IMIX).
[2] Size class (see Berglund 2005).

Based on Ecological Province models, habitat amounts for the flammulated owl range from a low of 1,975 ha (or enough nest habitat for about 108 pairs) on the Beaverhead-Deerlodge National Forest to 16,017 ha (or enough nest habitat for about 875 pairs) on the Nez Perce National Forest.

A second consideration is to provide well-distributed habitat. Few estimates of territory size are available for the flammulated owl. Multiplying the square root of the home range [11.1 ha (Linkhart 2001)] times 12 provides an estimate of the median dispersal distance of 40 km. Nesting habitat for the flammulated owl should be within 40 km of each other. This distance of 40 km may or may not be an underestimate given the ability of the flammulated owl to winter in eastern Mexico and return to breed as far north as British Columbia.

Groves et al. (1997), Wright et al. (1997), Linkhart (2001), and Woudenberg (2003) and others suggest habitat for the flammulated owl has and will decline due to fire suppression. Fire suppression permits young Douglas-fir trees to suppress the recruitment of shade intolerant and large diameter trees important to the flammulated owl and to reduce the amount of open understory needed by the owl as foraging areas.

Table 19 displays a comparison of relative forest composition and structure in 1938 to 1942 to current as sampled by FIA (Berglund 2005). The comparison of the 1938 to 1942 inventory to FIA in Table 19 shows that the open understory important to the flammulated owl has closed due to general and widespread increases in the relative abundance of Douglas-fir and the accompanying increases in the seedling/sapling seral stage on 11 of 12 National Forests.

Second, during the same interval (1938 to 1943 to present), the relative percent of large (sawtimber) ponderosa pine trees (important to the flammulated owl) declined on 9 National Forests while very slight increases occurred on three National Forests, the Helena, Lewis and Clark, and the Nez Perce (Table 19).

On the other hand, Douglas-fir in sawtimber size increased in abundance on 9 of 10 National Forests, the exception being the Lewis and Clark (Table 19), and often dramatically, e.g., 4.3 to 26.5% on the Bitterroot National Forest, suggesting an overall increase in habitat for the flammulated owl.

Short-term Viability

The four criteria to evaluate viability are 1) distribution and amounts of habitat, 2) human disturbance, 3) biotic interactions, and 4) managing for ecological processes.

Distribution of habitat.

Amounts of habitat. Habitat for the flammulated owl is abundant and widespread in the Northern Region (Table 18) supporting McCallum's (1994a: 1) statement that the flammulated owl "is perhaps the most common raptor of the montane forests of the western United States."

Habitat amounts for the flammulated owl range from a low of 1,975 ha (or enough nest habitat for about 108 pairs) on the Beaverhead-Deerlodge National Forest to 16,017 ha (or enough nest habitat for about 875 pairs) on the Nez Perce National Forest.

Human disturbance. Timber management (seed shelterwood, selection, salvage, and intermediate) in the Northern Region in 2004 amounted in total to 8581 ha of 7,375,840 forested ha in the Northern Region or 0.0001% of the landscape. Level of timber management in preceding years was 10,542 ha in 2003, 8516 ha in 2002, 5283 ha in 2001 and so on. Timber management is an insignificant influence on the landscape in comparison to suppression of fire. [see also Gallant et al. (2003) who concluded timber management in the GYE is not an issue compared to landscape changes].

Two additional human-related threats are use of playback of recorded calls during the breeding season that may disrupt courtship (Clark 1988) and use of pesticides near nest sites that reduce important insect prey (Reynolds et al. 1989).

Biotic interactions. Larger owls, accipiters, long-tailed weasels are direct threats to the flammulated owl and other woodpeckers may compete with the flammulated owl for nest cavities (McCallum 1994a, 1994b).

In British Columbia, the barred owl is known to harass the flammulated owl causing nest abandonment and probable loss of fledglings (Woudenberg and Christie 1997, Woudenberg 2003). The barred owl is on the increase in numbers in the western United States, including northern and central Idaho and northwest and north-central Montana (Accessed March 28, 2005; http://www.mbr-pwrc.usgs.gov/bbs) (1966-2003) at a rate that may exceed 1.5% per year in some areas.

As with the spotted owl (Kelly et al. 2003) and goshawk (Hanauska-Brown et al. 2003), the barred owl represents a significant influence on flammulated owl abundance and distribution. Virtually all of the current and highly modified forested landscape in the Northern Region is potential barred owl habitat (Peterson and Robins 2003). Areas of particularly suitable habitat for the barred owl are in central Idaho and east-central Montana.

The barred owl provides a biotic interaction with negative consequences to the flammulated owl.

Managing ecological processes. Virtually every author working with the flammulated owl (Groves et al. 1997, Linkhart 2001 and others) suggests fire suppression has been a negative influence on habitat. Whether enough fire can be introduced is unknown, and mechanical removal of understory, particularly in relatively large areas, may serve as an effective alternative to fire. Size of area to be restored is important (larger is better) to slow subsequent peripheral encroachment of understory, particularly by shade tolerant tree species.

Short-term viability of the flammulated owl in the Northern Region is not an issue given the following.

- No scientific evidence exists that the flammulated owl is in decreasing in numbers.

- Increases in the extent and connectivity of forested habitat have occurred since European settlement.

- Well-distributed and abundant flammulated owl habitat exists on today's landscape.

- Level of timber harvest (8581 ha of 9,045,255 ha or 0.0009% of the forested landscape in the Northern Region) is insignificant.

The barred owl represents a significant threat (predation) to the flammulated owl.

7. Pileated Woodpecker

Ecology, Behavior and Habitat

The pileated woodpecker in North America is only exceeded in size by the ivory-billed woodpecker in the southeastern United States and the imperial woodpecker in western Mexico. The pileated woodpecker's range extends from central British Columbia south into Northern California, east from Idaho across North Dakota (Dechant 2001, with the colonization by trees of an historic open North Dakota landscape) and east from a general line descending south from Minnesota to eastern Texas (as cited in Bull and Jackson 1995).

The pileated woodpecker is not considered to be migratory (Bull and Jackson 1995). The pileated woodpecker is most often associated with mature forests (Conner et al. 1976, Conner 1980, Shackelford and Conner 1997) although the presence of large trees for nesting is reported to be more important than forest age (Kirk and Naylor 1996, Giese and Cuthbert 2000). The pileated woodpecker is able to do well in young and fragmented forests with abundant remnant (older) structure (Mellon et al. 1992).

Many tree species are used by the pileated woodpecker to excavate nest cavities and selection of the tree appears to depend mainly on the availability of suitable trees (Kirk and Naylor 1996). The pileated can excavate a cavity in solid wood (Bull 1987) but most often uses trees partially softened by fungal decay (Conner et al. 1976, Bull 1987). Pileated woodpeckers excavate a new cavity each year and reuse of old cavities is rare (Bull and Jackson 1995).

Territory size varies considerably, ranging from 321 to 630 ha [(mean = 407 ± 110.3 ha (SE)] for seven pairs radio tracked, and a mean of 597 ± 338.1 ha for nine individuals who had lost a mate (Bull and Holthausen 1993). Based on eleven birds fitted with radio transmitters, Mellon et al. (1992) in western Oregon reported pileated woodpeckers had territories somewhat larger (mean = 478 ± 219 ha) than in eastern Oregon (Bull and Holthausen 1993). Eleven birds fitted with radio transmitters in Missouri had much smaller territories with a mean = 87.5 ± 31.6 ha (Renkin and Wiggins 1989).

Pileated woodpeckers are the only North American woodpecker that makes deep excavations in undecayed wood in search of food (Conner 1979, Bull et al. 1992, Bull and Jackson 1995, Bull and Holthausen 1993, Flemming et al. 1999). In summer, ants, particularly carpenter ants (Hoyt 1950), and other insects (including larvae of wood-boring beetles) are obtained on or near the surface of live and dead trees or by extensive excavation into partially decayed wood (Bull et al. 1986, 1992).

As a year-round resident, winter roosts are important and appear to be in habitats similar to that used during the breeding season (Bull and Jackson 1995). In winter, the pileated woodpecker excavates relatively sound wood around the base of a tree in search of carpenter ants (Hoyt 1950, Conner 1981, 1989, Bull et al. 1986, Flemming et al. 1999). The pileated woodpecker's territory appears to be defended all year (Bull and Jackson 1995).

Table 20. Summary of key habitat characteristics (mean ± SD unless noted, sample size in parentheses) for the pileated woodpecker in recent studies.

	Montana McClelland and McClelland (1999)	Alberta Bonar (2001)	Washington Aubrey and Raley (2002)
Tree size (cm)	53.3 ± 11.9 (20)	45.6 ± 3.5 (14)	72.0 ± 14.4 (33)
Tree height (m)	26.6 ± 12.0 (20)	43.1 ± 14.7% had tall stands (14)	24.0 ± 0.1 (33)

Predation is reported to be the main cause of mortality (Bonar 2001). Predators include the goshawk, Cooper's hawk, red-tailed hawk, great-horned owl, American marten, and gray fox.

Detailed information of the behavior and ecology of the Pileated woodpecker is provided by Bull and Jackson (1995) in *The Birds of North America No. 146.* Several internet website provide further detailed information on the pileated woodpecker (e.g., Accessed March 20, 2005; <http:/nhp.nris.state.mt.us/mbd>, and Accessed March 20, 2005; <http://imn.isu.edu/digitalatlas>).

Northern Region

At Coram Experimental Forest in northwestern Montana, McClelland and McClelland (1999) found that the pileated woodpecker preferred western larch (n = 51) as a nest tree but also used ponderosa pine (n = 18), black cottonwood (n = 15), aspen (n = 7), western white pine (n = 3), grand fir (n = 1) and Douglas-fir (n = 1).

Nest trees were similar in size to roost trees and both were typically snags (81% and 78% respectively) and with broken tops (McCelland and McClelland 1999). Trees used by the pileated woodpecker were larger and taller than in random sites. Hutto (1995) reported habitat use by the pileated woodpecker similar to McCelland and McClelland (1999) in the Northern Rocky Mountains, i.e., mature cottonwood bottoms, ponderosa pine, and larch stands but also reported use of mixed conifer and cedar-hemlock.

Bonar (2001) conducted a five-year study of the pileated woodpecker in the boreal forest in the Rocky Mountain foothills in west central Alberta (Table 20). Bonar (2001) used information based on 158 total nests, collected from 1982-1998, and 14 territories by following 32 birds equipped with radio transmitters.

Bonnar (2001) found the pileated woodpecker used all available habitats at all scales examined to select nest cavity trees and for foraging. Significant variables in predicting habitat characteristics of pileated woodpecker territories included stands => 7 m in height ($P = 0.011$), potential nest tree density ($P = 0.001$), winter foraging habitat ($P = 0.06$), and percent upland forest ($P = 0.003$).

The pileated woodpecker in Bonar's (2001) study did select substrates with carpenter ants and cavity trees with stem decay, specifically aspen infected with *Phellinus* fungus. This "suggests that pileated woodpeckers select nest cavity trees primarily because of tree characteristics and that selection at other scales relates to the availability of potential nest cavity trees" (page 65). Bonar (2001) found 22.3% of the available cavities were empty when inspected and empty cavities were present throughout the year

From 1990 to 1995, Aubrey and Raley examined habitat use by the pileated woodpecker in western Washington (Table 20). These authors used both playback of calls and telemetry to locate 25 nests. Overall, the pileated woodpecker preferred large trees but these cavity trees had less decay than roost sites, and 0.4 ha plots around nest sites had a higher density of both tree species and snags. Results of Aubrey and Raley (2002) are similar to that reported in Oregon by Bull (1987) in terms of use of large trees and snags.

The Regional nest site habitat relationships model for the pileated woodpecker (Table 21) and for the breeding season is based on two variables considered to be the most significant in the scientific literature. First, the dominance group is those tree species where the pileated is reported to have nested is included in the nest-site model. Second, tree size is included using the mean minus one standard deviation as the minimum size (i.e., from McClelland and McClelland 1997: Table 2, aspen). The assumption is that no upper limit exists in tree size selected as a nest cavity tree by the pileated woodpecker. The nest tree is the most important variable to estimate breeding habitat use by the pileated woodpecker (Kirk and Naylor 1996, Giese and Cuthbert 2003).

Cover is not included in the Regional nest site habitat relationships model. The pileated woodpecker is reported to use areas with 10% forest cover (Bonar 2001). The Forest Service's definition of forest cover includes those areas with =>10% tree cover.

The foraging model for the pileated woodpecker (Table 21) is based on habitat requirements to forage in winter (Bonar 2001). Winter is the critical period for the pileated woodpecker (Bonar 2001) as it is for many bird species (Perrins 1966, Nilsson 1987, Newton 1998, and others).

In winter, the pileated woodpecker forages largely on stubs and logs as small as 7.4 cm but 25 to 50 cm substrates are used in greater proportion than available (Bonar 2001). The model assumes no upper size limit exists to size of winter foraging substrate for the pileated woodpecker.

Habitat estimates for the pileated woodpecker based on the Regional nest tree habitat model (Table 21) show nest site habitat is abundant and well distributed across the Northern Region by National Forest (Table 22). Estimates of nest tree availability range from a low of 5,601 ha on the Helena National Forest to a high of 170,584 ha on the Idaho Panhandle National Forests.

Table 21. Pileated woodpecker nest and winter foraging habitat relationships model for the Northern Region and Ecological Provinces (Bailey 1996).

Model	Dominance group[1]	Nest model (tree size cm)	Winter foraging substrate model (cm)
Regional NRMEP MRMEP SRMEP	ABGR, ABGR-1MIX, IMXS, LAOC, LAOC-1MIX, PSME, PSME-1MIX, PIPO, PIPO-1MIX. TSHE, TSHE-1MIX, THPL, THPL-1MIX, POPUL, POPUL-1MIX, BEPA, BEPA-1MIX, TGCH, POTR5, POTR-1MIX, PIEN, PIEN-1MIX	> = 39	>= 25

[1] Douglas-fir (PSME), ponderosa pine (PIPO), western white pine (PIMO3), western red cedar, (THPL), western hemlock (TSME), larch (LOAC), grand fir (ABGR), lodgepole pine (PICO), birch (BEPA), aspen (POTR5), cottonwood (POPUL), tolerant grand fir, cedar, and hemlock (TGCH), POTR (cottonwood), tolerant grand fir western hemlock (TGCH), and no single dominant (IMIX). 1MIX refers to the dominance of one species within a sample. See Appendix 6 for detailed definitions.

Winter foraging habitat estimates for the pileated woodpecker based on the Regional foraging habitat model (Table 22) show winter foraging habitat is abundant and well distributed across the Northern Region by Ecological Province and Forest (Table 22). Estimates of winter foraging habitat for the pileated woodpecker range from a low of 14,444 ha on the Helena Nation Forest to a high of 287,801 ha on the Idaho Panhandle National Forests. Bonar (2001) estimates about 40 ha are required per pileated woodpecker pair in winter (or winter habitat adequate from a low of 361 pairs on the Helena National Forest to a high of 7,195 pairs on the Idaho Panhandle National Forests).

A second consideration is to provide well distributed habitat. Few estimates of the territory size are available for the pileated woodpecker. Territory size varies considerably, ranging from 321 ha to 630 ha (mean = 407 ± 110.3 ha) in northeastern Oregon (Bull et al. 1992) to Bonar's study of 23 territories (mean = 1,360 ± 762.2 ha).

Table 22. Summary of habitat estimates (ha) for the pileated woodpecker by Region, Ecological Province (Bailey 1996) (only pileated woodpecker habitat of Forest Service lands is included in Ecological Province estimates) and National Forest in the USDA Forest Service Northern Region.

Region and Ecological Province	Forest	Model	
		Nest	Winter foraging
Regional		550,007	859,782
NRMEP		400,889	640,409
	Idaho Panhandle	170,584	287,801
	Kootenai	45,825	86,638
	Flathead	22,461	38,726
	Lolo	40,097	63,726
	Bitterroot	18,321	31,604
	Clearwater	103,601	131,914
MRMEP		135,156	214,260
	Beaverhead-Deerlodge	12,838	19,751
	Helena	5,601	14,444
	Lewis and Clark	6,122	18,367
	Nez Perce	110,595	161,698
SRMEP		13,952	25,113
	Gallatin	13,952	25,113

A median dispersal distance (square root of 407 ha, the smallest mean home range reported in the west, times 12) (Bowman 2003) is estimated to be 240 km. Providing a spatially explicit map of well distributed breeding habitat centered on a nest tree or winter substrate habitat is technically impossible. A 240 km buffer placed around any snag >= 41 cm or around a >=21 cm snag located anywhere on an individual National Forest in the Northern Region would include the entire ownership on that particular National Forest.

Short-term Viability

The four criteria to evaluate viability are 1) distribution and amounts of habitat, 2) human disturbance, 3) biotic interactions, and 4) managing for ecological processes.

Distribution of habitat. The median dispersal distance of 240 km for the pileated woodpecker extends farther than the most extreme distance, point to point, within the boundaries of any National Forest in the Northern Region.

Well-distributed habitat is not an issue for the pileated woodpecker in the Northern Region.

Amounts of habitat. Habitat estimates for the pileated woodpecker based on the Regional nest tree habitat relationships model (Table 21) show nest site habitat is abundant and well distributed across the Northern Region by and National Forest (Table 22). Estimates of nest tree availability Estimates of nest tree availability range from a low of 5,601 ha on the Lewis and Clark National Forest to a high of 170,584 ha on the Idaho Panhandle National Forests.

Winter foraging habitat estimates for the pileated woodpecker show winter foraging habitat based on the Regional winter foraging substrate model (Table 21) is abundant across the Northern Region by Ecological Province and Forest (Table 22). Bonar (2001) estimates about 40 ha are required per pileated woodpecker pair in winter (or winter habitat adequate from a low of 361 pairs on the Helena National Forest to a high of 7,195 pairs on the Idaho Panhandle National Forests).

Habitat on today's landscape is very abundant for the pileated woodpecker.

Human disturbance. Timber harvest may affect the availability of nest trees (Kirk and Naylor 1996, Giese and Cuthbert 2003) and winter foraging habitat (Bonar 2001). Timber management (seed shelterwood, selection, salvage, and intermediate) in the Northern Region in 2004 amounted in total to 8581 ha (of 9,045,255 forested ha in the Northern Region or 0.0009% of the landscape). Level of timber management is insignificant given the changes on the landscape due to fire suppression (Gallant et al. 2003, Hessburg and Agee 2003 and others).

Biotic interactions. No biotic interactions that negatively affect the pileated woodpecker are reported in the literature.

Managing ecological processes. Today's landscape with high numbers of intermediate sized trees (Hessburg et al. 2003) provide increased mounts of forage substrates within the range reported by Bonnar (2001). Pileated woodpeckers are known to feed on wood-boring beetles (as cited in Bonar 2001) and benefit from the substantial increases in extent of post-fire and insect outbreak habitats (Table 14).

Short-term viability of the pileated woodpecker in the Northern Region is not an issue given the following.

- No scientific evidence exists that the pileated woodpecker is decreasing in numbers.
- Increases in the extent and connectivity of forested habitat have occurred since European settlement.

- Well-distributed and abundant pileated woodpecker habitat exists on today's landscape.

- Level of timber harvest (8581 ha of 9,045,255 or 0.0009% of the forested landscape in the Northern Region) is insignificant.

8. Ecosystem Sustainability and Long-term Species Viability

Ecosystem Sustainability

Holling (1992) describes four phases to an ecosystem: 1) reorganization where the amounts of nutrients, carbon, and minerals and the intensity and type of ecological process interact to shape the future (by succession) ecosystem; 2) exploitation where succession begins and accessible nutrients are adsorbed; 3) conservation where climax species store carbon and other important resources; and 4) release of energy, nutrients, carbon, and minerals due to fire, wind through, disease or other factor causing the death of vegetation (Samson and Knopf 1996) (Figure 1).

Understanding an ecosystem cycle is essential to understanding the systems ability to function and provide essential services and to conserve biodiversity element such as species that depend on a particular ecosystem (Allen and Holling 2002).

Altering one of the four stages can lead to a new ecosystem with self-reinforcing properties. An example is the invasion of native sagebrush systems of the Great Basin in the western United States by an exotic species—cheat grass (Anderson and Inouye 2001). Cheat grass out competes native species (reorganization), increases in abundance (exploitation), alters the release of energy (increasing the fire frequency) (conservation) and, rather than returning to the natural ecosystem, exists the ecosystem cycle.

Figure 1. Flow of events including exploitation, conservation, release, and reorganization that describe an ecosystem cycle (after Holling 1992), ecosystem conservation is a natural figure 8. Exit from the cycle at the left leads to ecosystem change and increases in costs to management (Samson and Knopf 1996a).

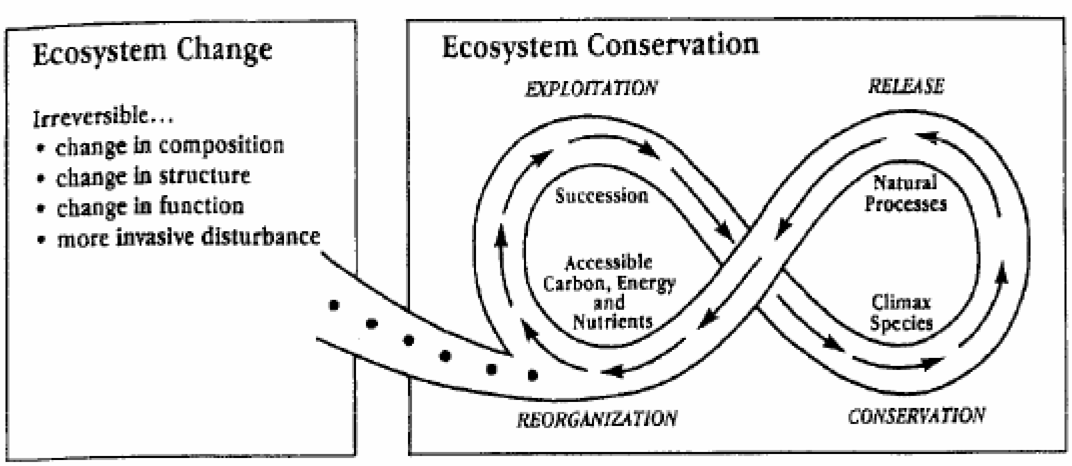

Table 23. Representativeness, Redundancy and Resiliency as the evaluation criteria for long-term population viability (after Shaffer et al. 2002).

Principle	Effect	Advantage	Concerns
Representative	Ecological/evolutionary habitat for all native species and reduces factors related to human disturbance.	Promotes population stability and reduces or eliminates negative biotic interactions.	Costs to restore native landscapes are high and increases with time.
Redundancy	Provides multiple examples of native habitat ensuring opportunities for genetic variation and “backup” in terms of habitat in case of native predation or disease.	Promotes stability in populations that exists as subpopulations and ensures habitat is distributed across the landscape.	More homogeneous and well connected landscapes follow suppression of natural processes.
Resiliency	Ensure a full range of seral stages are present on a landscape where all natural processes—large and small—operate within their natural range.	Promotes habitat for all species native to a landscape in a pattern consistent with life history requirements for all native species.	Ecosystems are no longer resilient causing loss of ecosystem elements and more extensive and invasive ecological processes.

An exit from the ecosystem cycle is evident in changes, most often irreversible, in ecosystem composition, structure, function, and in patterns in ecological processes (Figure 1). Cheat grass in the Great Basin of the United States has created an annual-based ecosystem versus the historic and relatively long-lived shrub-based ecosystem (Anderson and Inouye 2001). Without very large investments to restore native species and ecological processes, cheat grass will become more extensive and will continue to further create a self-reinforcing ecosystem (or a new “figure 8”). This new ecosystem will have habitats unlike any suitable for species that evolved within the historic Great Basin.

Many forests of the Rocky Mountains are either at the transition from ecosystem conservation to ecosystem change (Figure 1) or have shifted to a new and self-reinforcing pattern of ecological processes. As compared to historic, large fires lead to large patches of similarly aged trees, that

Table 24. Habitat conditions on the basis for long-term viability in the USDA Forest in the USDA Forest Service Northern Region for the goshawk, black-backed woodpecker, flammulated owl, and pileated woodpecker using the three R's.

Principle	Goshawk	Black-backed woodpecker	Flammulated owl	Pileated woodpecker
Representativeness	Low	Low	Low	Low
Redundancy	Low	Low	Low	Low
Resiliency	Low	Low	Low	Low

at some point, collectively are vulnerable to fire. Large insect outbreaks create stands similar in age, which in turn, reach a future point when stands due to age collectively will be vulnerable to another large insect outbreak, a self-reinforcing pattern.

Table 24 summarizes habitat conditions using the three R's (Table 23) as the basis for *long-term* viability for the goshawk, black-backed woodpecker, flammulated owl, and pileated woodpecker.

Restoring western forests to a pattern more characteristic of historic is expensive, as indicated by the Healthy Forest Initiative.

Long-term Viability

Long-term viability is closely associated with the habitat in which the species evolved (Hunter et al. 1988). Shaffer et al. (2002) describes this preferred habitat for long-term viability by three ecological and non-statistical concepts—the three R's (Table 23). The expectation is that each of the three R's would be rated as "high" in order to ensure long-term population viability.

For each species (Table 24), the three R's are low due to the following.

- A lack of Representativeness. Major changes since European settlement in grasslands (losses), shrublands (increases) and forest landscape structure (increases in mid-aged forests) and composition (increases in shade tolerant species). Today's landscape is no longer representative in virtually any way to that in which the species evolved.

- A lack of Redundancy. Few examples of the full natural landscape exist and increased areas of intermediate aged forest and increased connectivity of the landscape threatens key remaining elements of biodiversity such as areas of oldgrowth that no longer persist in fire-protected refugia but are embedded in a well-connected matrix of intermediate-aged forest that permits the rapid spread of fire and insect outbreaks with a spatial-temporal pattern unlike historic landscape.

• A lack or Resiliency. Massive landscape changes due to the irreversible historic loss of open grasslands because of the conversion of grasslands to croplands and and due to the increase in intermediate-aged forests because of prior fire suppression in forested systems is leading to further changes (larger and more intense) in ecological processes, which, in turn eliminates the Resiliency of a system operating within its natural range of variation.

Providing for ecosystem sustainability (Figure 1) and the long-term viability for the four species under consideration in this assessment requires a much larger, more widespread and active vegetation management program than evident today.

The need to manage the current (and soon to be irreversible if similar to other ecosystems) changes in the ecosystems of the Northern Rocky Mountains is urgent in that costs to do so will only increase. Environments in which at least 426 vertebrates and a very large number of lesser known taxa will continue to depart from that which influenced their evolution (see Arnaiz-Villena et al. 2001 for how evolution at the subspecific level is possible since the last glacial advance suggesting historic habitats although variable are important).

9. Summary[1]

• Ecosystems partially under the management of the Northern Region of the Forest Service have undergone profound changes since European settlement. Native prairies in North Dakota, South Dakota and Montana have declined in area (Samson and Knopf 1996b) and are highly fragmented and exist in a matrix of agricultural and other lands (Samson et al. 2004). In sharp contrast, area of forest in North Dakota, South Dakota, Montana and Idaho has increased in area and connectivity is at an all-time high at least since 1800 (Hessburg and Agree 2003, Hessburg et al. 2004). The prairies and forests do share three characteristics: 1) a relative decline in relative extent of early and late stages of vegetation succession; 2) sharp increases in the mid successional stage vegetation (Knopf and Samson 1997, Hessburg and Agee 2003); and 3) increasing threats due to species not native to an ecosystem (Knopf and Samson 1997, Hanauska-Brown et al. 2003 and others).

• Viability is not yet a mature science (Samson 2002) and should be principle based (Beissinger and Westphal 1998, Beissinger 2002, Ralls et al. 2002, Shaffer 2002) until long-term demographic information is available permitting more quantitative approaches.

• The National Forest Management Act (1976) requires that a diversity of plant and animals be maintained. The four species considered in this conservation assessment are not at risk and habitat for each has increased since the arrival of Europeans—short-term viability is neither an issue or concern.

• The most urgent issue is to restore the sustainability of the grassland and forested ecosystems to a condition more like historic (Pre-European)—therefore provide for the long-term viability of the four species considered in this assessment as well as all 426 vertebrates. This will require a very aggressive program in vegetation management.

[1] A detailed assessment of short- and long-term viability for the Idaho Panhandle National Forests is included in Appendix 9.

10. Literature Cited

Agee, J. K. 1998. The landscape ecology of western forest fire regimes. Northwest Science 72: 24-34.

Allen, C. R., and C. S. Holling. 2002. Cross-scale structure and scale breaks in ecosystems and other complex systems. Ecosystems 5: 315-318.

American Ornithologists' Union. 1998. Check-list of North American birds. 7th ed. American Ornithologists' Union, Washington DC, USA.

Amman, G. W., and W. E. Cole. 1983. Mountain pine beetle dynamics in lodgepole pine forests part II: population dynamics. USDA Forest Service General Technical Report INT-145. Ogden, Utah, USA.

Angelstam, P., and G. Mikusinski. 1994. Woodpecker assemblages in natural and managed boreal and hemiboreal forest - a review. Annuals Zoologica Fennici 31: 157-172.

Apfelbaum, S., and A. Haney. 1981. Bird populations before and after wildlife in a Great Lakes pine forest. Condor 83: 347-354.

Anderson, J. E., and R. S. Inouye. 2001. Landscape-scale changes in plant species abundance and biodiversity of a sagebrush steppe over 45 years. Ecological Monographs 71: 531-556.

Arnaiz-Villena, A., J. Guillen, V. Ruiz-Del-Valle, E. Lowy, J. Zamora, P. Varela, D. Stefani, and L. M. Allende. 2001. Phylogeography of crossbills, bullfinches, grosbeaks, and rosefinches. Cellular and Molecular Life Sciences 8: 1159-1166.

Arno, S. F., and G. E. Gruell. 1986. Douglas-fir encroachment in to mountain grasslands in southwestern Montana. Journal of Range Management 39: 272-275.

Aubrey, K. B., and C. M. Raley. 2002. Selection of nest and roost trees by pileated woodpeckers in coastal forests of Washington. Journal of Wildlife Management 66: 392-406.

Bailey, R. G. 1996. Ecosystem geography. Springer-Verlag, New York, New York, USA.

Balda, R., B. C. McKnight, and C. D. Johnson. 1975. Flammulated owl migration in the southwestern United States. Wilson Bulletin 87: 520-533.

Baldwin, P. 1960. Overwintering of woodpeckers in bark-beetle-infested spruce forests in Colorado. International Ornithological Congress 12: 71-84.

Baldwin, P. 1968. Woodpecker feeding on Engelmann spruce beetle in windthrown trees. USDA Forest Service Research Note RM-105, Fort Collins, Colorado, USA.

Bangs, O. 1900. The American three-toed woodpeckers. Auk 17: 127-142.

Bart, J., S. Droege, P. Geissler, B. Peterjohn, and C. J. Ralph. 2004. Density estimation in wildlife surveys. Wildlife Society Bulletin 32: 1242-1247.

Bebi, P., D. Kulakowski, and T. T. Veblin. 2003. Interactions between fire and spruce beetles in a subalpine Rocky Mountain forest landscape. Ecology 84: 362-371.

Beier, P., and J. E. Drennen. 1997. Forest structure and prey abundance in foraging areas of northern goshawks. Ecological Applications 7: 564-571.

Beissinger, S. R. 2002. Population viability analysis: past, present and future. Pages 5-17 *in* Population viability analysis. S. R. Beissinger, and D. R. McCullough, editors. University of Chicago Press, Chicago, Illinois, USA.

Beissinger, S. R., and M. I. Westfall. 1998. On the use of demographic models of population viability in endangered species management. Journal of Wildlife Management 62: 821-841.

Belovsky, G. F., C. Mellison, C. Larson, and P. A. Van Zandt. 2002. How good are PVA models? Resting their predictions with experimental data on the brine shrimp. Pages 257-283 *in* Population viability analysis. S. R. Beissinger, and D. R. McCullough, editors. University of Chicago Press, Chicago, Illinois, USA.

Bent, A. C. 1938. Flammulated screech owl. Pages 291-295 *in* Life histories of North American birds of prey. US National Museum Bulletin 170, Part 2, Washington, DC, USA.

Berglund, D. 2005. Comparison of 1937-1948 timber inventories and current FIA data. Unpublished mimeo on file, Flathead National Forest, Kalispell, Montana, USA.

Blackford, J. L. 1955. Woodpecker concentrations in burned forest. Condor 57: 28-30.

Bloxton, T. D., Jr. 2002. Prey abundance, space use, demography, and forging habitat of northern goshawks in western Washington. Master's thesis, University of Washington, Seattle, Washington, USA.

Boch, C. E., and J. H. Boch. 1974. On the geographical ecology and evolution ofthree-toed woodpeckers, *Picoides tridactylus* and *P. arcticus*. American Midland Naturalist 92: 397-405.

Boch, C. E., and J. F. Lynch. 1970. Breeding bird populations of burned and unburned conifer forest in the Sierra Nevada. Condor 72: 182-189.

Bonar, R. L. 2001. Pileated woodpecker habitat ecology in the Alberta foothills. Dissertation, University of Alberta, Edmonton, Canada.

Bourdo, E. A. and G. A. Hesterburg. 1951. Observations on the arctic three-toed woodpecker. Jack-Pine Warbler 29: 78-81.

Bowman, J. 2003. Is dispersal distance of birds proportional to territory size? Canadian Journal of Zoology 81: 195-202.

Boyce, M. S. 1992. Population viability analysis. Annual Review of Ecology and Systematics 23: 481-506.

Braun, C. E., J. H. Henderson, M. R. Fuller, Y. B. Linhart, and C. D. Marti. 1996. Northern goshawk and forest management in the southwestern United States. The Wildlife Society Technical Review 96-2.

Bright-Smith, D. J., and R.W. Mannan. 1994. Habitat use by breeding male northern goshawks in northern Arizona. Studies in Avian Biology 16: 58-65.

Bull, E. L. 1980. Bird responses to beetle-killed lodgepole pine. The Murrelet 64: 94-96.

Bull, E. L. 1983. Longevity of snags and their use by woodpeckers. Pages 64-68 *in* Snag habitat management. J. W. Davis, G. A. Goodwin and R. A. Ockenfels, editors. USDA Forest Service General Technical Report RM-99, Fort Collins, Colorado, USA.

Bull, E. L. 1987. Ecology of the pileated woodpecker in northeastern Oregon. Journal of Wildlife Management 51: 472-481.

Bull, E. L., and R. G. Anderson. 1978. Notes of flammulated owl in northeastern Oregon. Murrelet 59: 26-28.

Bull, E. L., S. R. Peterson, and J. W. Thomas. 1986. Resource partitioning among woodpeckers in northeastern Oregon. USDA Forest Service Research Note PNW-444.

Bull, E. L., A. L. Wright, and M. G. Henjum. 1990. Nesting habitats of flammulated owls in Oregon. Journal of Raptor Research 24: 52-55.

Bull, E., R. S. Holthausen, and M. G. Henjum. 1992. Roost trees used by pileated woodpeckers in northeastern Oregon. Journal of Wildlife Management 56: 786-793.

Bull, E. L., and R. S. Holthausen. 1993. Habitat use and management of pileated woodpeckers in northeastern Oregon. Journal of Wildlife Management 57: 335-345.

Bull, E. L., and J. A. Jackson. 1995. Pileated woodpecker (*Dryocopus pileatus*). No. 148. A. Poole, and F. Gill, editors. The Academy of Natural Sciences, Philadelphia, Pennsylvania, and The American Ornithologists' Union, Washington, DC, USA.

Camp, A., C. Oliver, P. Hessburg, and R. Everett. 1997. Predicting late-successional fire refugia pre-dating European settlement in the Wenatchee Mountains. Forest Ecology and Management 95: 6-77.

Caton, E. L. 1996. Effects of fire and salvage logging on the cavity-nesting bird community in northwestern Montana. Dissertation, University of Montana, Missoula, Montana, USA.

Christie, D. A., and A. M. van Woudenberg. 1997. Modeling critical habitat for flammulated owls (*Otus flammeolus*). Pages 97-106 *in* Biology and conservation of owls of the northern hemisphere. J. R. Duncan, D. H. Johnson, and T. H. Nichols, editors. USDA Forest Service General Technical Report NC-190, St. Paul, Minnesota, USA.

Clark, R. J. 1988. Survey techniques for owl species in the northeast. Pages 318-327 *in* National Wildlife Federation Proceedings of the northeast raptor management symposium and workshop. National Wildlife Federation Technical Series No. 13.

Clough, L. 2000. Nesting habitat selection and productivity of northern goshawks in west-central Montana. Master's thesis, University of Montana, Missoula, Montana, USA.

Connor, R. N. 1979. Seasonal changes in woodpecker foraging methods: strategies for winter survival. Pages 95-105 *in* The role of insectivorous birds in forest ecosystems. J. C. Dicks, R. N. Conner, R. R. Fleet, J. C. Kroll, and J. A. Jackson, editors. Academic Press, New York, New York, USA.

Connor, R. N. 1980. Foraging habitats of woodpeckers in southwestern Virginia. Journal of Field Ornithology 51: 119-127.

Connor, R. N. 1981. Seasonal changes in woodpecker foraging patterns. Auk 98: 562-570.

Connor, R. N. 1989. Foraging habitats of woodpeckers in southeastern Virginia. Journal of Field Ornithology 51: 119-127.

Connor, R. N., O. K. Miller, Jr., and C. S. Atkinson. 1976. Woodpecker dependence on trees infected by fungal heart rots. Wilson Bulletin 88: 575-581.

Coues, E. 1893. The history of the Lewis and Clark Expedition. Francis P. Harper, New York, New York, USA.

Crocket, A. B., and P. L. Hansley. 1978. Apparent response of Picoides woodpeckers to outbreaks of the pine bark beetle. Western Birds: 67-70.

Daw, S. K., and S. Destafano. 2001. Forest characteristics of northern goshawk stands and post-fledging areas in Oregon. Journal of Wildlife Management 65: 59-65.

Dechant, J. A. 2001. Range expansion of the pileated woodpecker in North Dakota. Prairie Naturalist 33: 163-182.

Dixon, R. D., and V. A. Saab. 2000. Black-backed woodpecker (*Picoides arcticus*). No. 509. In Birds of North America. A. Poole, and F. Gill, editors. The Academy of Natural Sciences, Philadelphia, Pennsylvania, and The American Ornithologists' Union, Washington, DC, USA.

Doyle, F. I., and J. N. M. Smith. 1994. Population responses of northern goshawks to the 10-year cycle in numbers of snowshoe hares. Studies in Avian Biology 16: 122-29.

Drennen, J. E., and P. Beier. 2003. Forest structure and prey abundance in winter habitat of northern goshawks. Journal of Wildlife Management 67: 177-185.

Dunham, S., L. Butcher, D. A. Charlet, and J. M. Reed. 1996. Breeding range and conservation of flammulated owls (*Otus flammeolus*) in Nevada. Journal of Raptor Research 30: 189-193.

Fayt, P. 2003. Insect prey population changes in habitats with declining vs. stable three-toed woodpecker (*Picoides tridactylus*) populations. Ornis Fennica 80: 182-192.

Flemming, S. P., G. L. Holloway, E. J. Watts, and P. S. Lawrence. 1999. Characteristics of foraging trees selected by pileated woodpeckers in New Brunswick. Journal of Wildlife Management 63: 461-469.

Foster, D. R., D. A. Orwig, and J. S. McLachlan. 1996. Ecological and conservation insights from reconstructive studies of temperate old-growth forests. Trends in Ecology and Evolution 11: 419-424.

Frankel, O. H., and M. E. Soule. 1981. Conservation and evolution. Cambridge University Press, Cambridge, United Kingdom.

Furniss, R. L. 1965. Susceptibility of fire-injured Douglas-fir to bark beetle attack in southern Idaho. Journal of Forestry 63: 11-13.

Gallant, A., A. J. Hansen, J. S. Councilman, D. K. Monte, and D. W. Betz. 2003. Vegetation dynamics under fire exclusion and logging in a Rocky Mountain watershed. Ecological Applications 13: 385-403.

Gibbs, J., and J. Faaborg. 1991. Estimating the viability of ovenbird and Kentucky warbler populations in forest fragments. Conservation Biology 4: 193-196.

Giese, C. L. A, and F. J. Cuthbert. 2000. Influence of surrounding vegetation on woodpecker nest tree selection in oak forests of the upper Midwest. Forest Ecology and Management 179: 523-534.

Gilpin, M. E., and M. E. Soule. 1986. Minimum viable populations: processes of species extinction. Pages 19-34 *in* Conservation biology: the science of scarcity and diversity. M. E. Soule, editor. Sinauer Associates, Sunderland, Massachusetts, USA.

Giroux, J. F., and J. P. Savard. 2003. Snag use by foraging black-backed woodpeckers (*Picoides arcticus*) in a recently burned eastern boreal forest. Auk 120: 505-511.

Good, R. E. 1998. Factors affecting the relative use of northern goshawk (*Accipiter gentilis*) kill areas in south central Wyoming. Master's thesis, University of Wyoming, Laramie, Wyoming, USA.

Goggans, R. 1986. Habitat use by flammulated owls in northeastern Oregon. Master's thesis, Oregon State University, Corvallis, Oregon, USA.

Groom, M. J., and M. A. Pascal. 1998. The analysis of population persistence: an outlook on the practice of viability analysis. Pages 2-27 *in* Conservation biology for the coming decade. P. L. Fiedler, and P. M. Kareiva, editors. Chapman and Hall, New York, New York, USA.

Groot, P., and R. W. Nott. 2004. Response of the whitespotted sawyer beetle, *Monochamus s. scutellatus*, and associated beetles to pheromes of some *Ips* and *Dendroctonus* bark beetles. Journal of Applied Entomology 128: 483-488.

Groves, C., T. Fredrick, G. Frederick, E. Atkinson, M. Atkinson, J. Shepard, and G. Servheen. 1997. Density, distribution, and habitat of flammulated owls in Idaho. Great Basin Naturalist 57: 116-123.

Gruell, G. E. 1983. Fire and vegetation trends in the Northern Rockies: interpretations from 1871-1892 photographs. USDA Forest Service General Technical Report INT-158, Ogden, Utah, USA.

Gurevitch, J., P. S. Curtis, and M. H. Jones. 2001. Meta-analysis in ecology. Advances in Ecological Research 32: 200-241.

Habeck, J. R. 1994. Using General Office records to assess forest succession in ponderosa pine-Douglas-fir forests in western Montana. Northwest Science 68: 69-78.

Hammond, H. E. J., D. W. Langor, and J. R. Spence. 2004. Saproxylic beetles (Coleoptera) using Populus in boreal aspen stands of western Canada: spatiotemporal variation and conservation of assemblages. Canadian Journal of Forest Research 34: 1-19.

Hanauska-Brown, L. A. 2000. Evaluation of northern goshawk (*Accipiter gentilis*) productivity, nestling growth, and adult health in relation to a central Idaho habitat potential model. Master's thesis, Boise State University, Boise, Idaho, USA.

Hanauski-Brown, L. A., M. J. Bechard, and G. J. Roloff. 2003. Northern goshawk breeding ecology and nestling growth in mixed conifer forests of west-central Idaho. Northwest Science 77: 331-339.

Hargis, C. D., C. McCarthy, and R. D. Perloff. 1994. Home ranges and habitats of Northern Goshawks in eastern California. Studies in Avian Biology 16: 66-74.

Harris, M.A. 1982. Habitat use among woodpeckers in forest burns. Master's thesis, University of Montana, Missoula, Montana, USA.

Haufler, J. B., R. K. Baydack, H. Campa, H. III, B. J. Kernohan, C. Miller, L. J. O'Neil, and L. Waits. 2002. Performance measures for ecosystem management and ecological sustainability. The Wildlife Society Technical Review 02-1.

Hayes, J. L., and G. E. Daterman. 2001. Bark beetles (Scolytidae) in eastern Oregon and Washington. Northwest Science 75: 21-30.

Hayward, G. D., and R. E. Escano. 1989. Goshawk nest-site characteristics in western Montana and northern Idaho. Condor 91: 476-479.

Hayward, G. D., and J. Verner. 1994. Flammulated, boreal, and great gray owls in the United States: A technical conservation assessment. USDA Forest Service General Technical Report RM-253, Fort Collins, Colorado, USA.

Heinselman, M. L. 1973. Fire in the virgin forests of the Boundary Waters Canoe Area, Minnesota. Quaternary Research 3: 329-382.

Hejl, S., and M. McFadzen. 1998. Maintaining fire-associated bird species across forest landscapes in the Northern Rockies. 1998 interim report. USDA Forest Service Rocky Mountain Research Station, Missoula, Montana, USA.

Hessburg, P. F., and J. K. Agee. 2003. An environmental narrative of inland northwest United States Forest. Forest Ecology and Management 178: 23-59.

Hessburg, P. F., J. K. Agee, and J. F. Franklin. 2004. Dry forests and wildlife fires in the inland Northwest USA: contrasting landscape ecology of the pre-settlement and modern eras. Forest Ecology and Management. In press.

Higgens, K. F. 1986. Interpretation and compendium of historical fire accounts in the northern Great Plains. USDI Fish and Wildlife Research Publication 161, Washington, DC, USA.

Hoffman, N. J. 1997. Distribution of Picoides woodpeckers in relation to habitat disturbance within the Yellowstone area. Master's thesis, Montana State University, Bozeman, Montana, USA.

Holling, C. S. 1992. Cross-scale morphology, geometry, and dynamics of ecosystems. Ecological Monographs 62: 447-502.

Howie, R. R., and R. and Ritcey. 1987. Distribution, habitat selection, and densities of flammulated owls in British Columbia. Pages 249-254 *in* Biology and Conservation of Owls. R. W. Nero, R. J. Clark, R. J. Knapton, and R. H. Hamre, editors. USDA Forest Service General Technical Report RM-142, Fort Collins, Colorado, USA.

Hoyt, J. S. 2000. Habitat associations of black-backed *Picoides arcticus* and three-toed *P. tridactylus* woodpeckers in the northeastern boreal forest of Alberta. Dissertation, University of Alberta, Edmonton, Alberta, Canada.

Hoyt, J. S, and S. J. Hannon. 2002. Habitat associations of black-backed and three-toed woodpeckers in the boreal forest of Alberta. Canadian Journal of Forest Research 32: 1881-1888.

Hoyt, S. Y. 1950. The feeding ecology of the pileated woodpecker. Bulletin of the Massachusetts's Audubon Society 34: 99-103.

Hughes, K. K. 2000. Foraging ecology of Picoides woodpeckers in relation to ponderosa pine decay dynamics. Master's thesis, University of Idaho, Moscow, Idaho, USA.

Hunter M.L. Jr.; G.L. Jacobson, Jr.; and T. Webb III. 1988. Paleoecology and the coarse-filter approach to maintaining biological diversity. Conservation Biology 2: 375-385.

Hurlbert, S. H. 1984. Pseudoreplication and the design of ecological field experiments. Ecological Monographs 54:187-211.

Hutto, R .L. 1995. Composition of bird communities following stand replacement fires in Northern Rocky Mountain (U.S.A.) conifer forests. Conservation Biology 9: 1041-1058.

Johnson, N. K., and W. C. Russell. 1962. Distribution data on certain owls in the western Great Basin. Condor 64: 513-514.

Jones, J., P. J. Doran, and R. T. Holmes. 2003. Climate and food synchronize regional bird abundances. Ecology 84: 3024-3032.

Joy, S. M. 2002. Northern goshawk habitat on the Kaibab National Forest in Arizona: factors affecting nest locations and territorial quality. Dissertation, Colorado State University, Fort Collins, Colorado, USA.

Kelly, E. G., E. D. Forsman, and R. G. Anthony. 2003. Are barred owls displacing spotted owls? Condor 105: 45-53.

Kennedy, P. L. 1997. The northern goshawk (*Accipter gentilis atricapillus*): is there evidence of a population decline. Raptor Research 31:95-106.

Kennedy, P. L. 2003. Northern goshawk (*Accipiter gentilis atricapillus*): a technical conservation assessment. Unpublished report, USDA Forest Service, Rocky Mountain Region, Species Conservation Project, Denver, Colorado, USA.

Kirk, D. A., and B. J. Naylor. 1996. Habitat requirements of the pileated woodpecker (*Dryocopus pileatus*) with special reference to Ontario. Ontario Ministry of Environment, South Central Science and Technology Report 46, Toronto, Ontario, Canada.

Knopf, F. L., and F. B. Samson. 1997. Ecological Studies 125. Ecology and conservation of great plains vertebrates. Springer-Verlag, New York, New York, USA.

Koenig, W. D., P. N. Hooge, M. T. Stanback, and J. Haydock. 2000. Natal dispersal in the cooperatively breeding acorn woodpecker. Condor 102: 492-502.

Koplin, J. R. 1969. The numerical response of woodpeckers to insect prey in a subalpine forest in Colorado. Condor 71: 436-438.

Koplin, J. R. 1972. Measuring predator impact of woodpeckers on spruce beetles. Journal of Wildlife Management 36: 308-320.

Kroll, J. C., and R. R. Fleet. 1978. Impact of woodpecker predation on over-wintering within tree populations of the southern pine beetle. Pages 269-281 *in* The role of insectivorous birds in forest ecosystems. J. G. Dickson, R. N. Conner, R. R. Fleet, J. A. Jackson, and J. C. Froll, editors. Academic Press, San Francisco, California, USA.

La Sorte, F. A., R. W. Mannan, R. T. Reynolds, and T. G. Grubb. 2004. Habitat associations of sympatric red-tailed hawks and northern goshawks on the Kaibab Plateau. Journal of Wildlife Management 68: 307-317.

Larocque, F. A. 1934. The journals of Francois Antoine Larocque from the Assiniboine River to Yellowstone-1805. R. Hazlitt, translator and editor. The Frontier 14: 241-247, 332-339, 15: 67-75, 88.

Lesica, P., and S. V. Cooper. 1992. Presettlement vegetation of southern Beaverhead County, Montana. Unpublished report, Natural Heritage Program, Helena, Montana, USA.

Lester, A. M. 1980. Numerical response of woodpeckers and their effect on mortality of mountain pine beetles in lodgepole pine in northwestern Montana. Master's thesis, University of Montana, Missoula, Montana, USA.

Linkhart, B. D. 2001. Life history characteristics and habitat quality of flammulated owls (*Otus flammeolus*) in Colorado. Dissertation, University of Colorado, Boulder, Colorado, USA.

Linkhart, B. D., R. T. Reynolds, and R. A. Ryder. 1998. Home range and habitat of breeding flammulated owls in Colorado. Wilson Bulletin 110: 342-351.

Ludwig, D. 1996. Uncertainty and the assessment of extinction probabilities. Ecological Applications 6: 1067-1076.

Ludwig, D. 1999. Is it meaningful to estimate the probability of extinction? Ecology 80: 298-310.

Marshal, J. T. 1939. Territorial behavior of the flammulated owl. Condor 1: 71-78.

Marshall, D. B. 1992. Status of the black-backed woodpecker in Oregon and Washington. In Bibliography of selected literature regarding the management of cavity excavators in east side habitats: Oregon and Washington. USDA Forest Service, LaGrande, Oregon, USA.

Marti, C. D. 1997. Flammulated owls (*Otus flammeolus*) breeding in deciduous forests. Pages 262-266 in 1997 Biology and conservation of owls of the northern hemisphere. J. R. Duncan, D. H. Johnson, and T. H. Nichols, editors. USDA Forest Service General Technical Report NC-190, St. Paul, Minnesota, USA.

Martin, K., and J. M. Eadie. 1999. Nest webs: A community-wide approach to the management and conservation of cavity nesting birds. Forest Ecology and Management 115: 243-257.

Mayfield, H. 1958. Nesting of black-backed and three-toed woodpeckers in Michigan. Wilson Bulletin 2: 195-196.

McAllister, K. 2004. Letter to the National Forests and Grassland, on file, Northern Region, USDA Forest Service, Missoula, Montana, USA.

McCallum, D. A. 1994a. Flammulated owl (*Otus flammeolus*). In Birds of North America. No. 93. A. Poole, and F. Gill, editors. The Academy of Natural Sciences, Philadelphia, Pennsylvania, and The American Ornithologists' Union, Washington, DC, USA.

McCallum, D. A. 1994b. Review of technical knowledge: flammulated owls. Pages 14-46 *in* Flammulated, boreal, and great gray owls in the United States: a technical conservation assessment. USDA Forest Service General Technical Report RM-253, St. Paul, Minnesota, USA.

McCallum, D. A., and F. R. Gehlback. 1988. Nest-site preferences of flammulated owls in western New Mexico. Condor 90: 653-661.

McClelland, B. R., and P. T. McClelland. 1999. Pileated woodpecker nest and roost trees in Montana: links with old growth and forest "health." Wildlife Society Bulletin 27: 846- 857.

McCullough, D. G., R. A. Werner, and D. Neuman. 1998. Fire and insects in northern and boreal ecosystems on North America. Annual Review of Entomology 43: 107-127.

McCullough, D. R. 1978. Population dynamics of the Yellowstone grizzly bear. Pages 173-196 *in* Dynamics of large mammal populations. C. W. Fowler, and T. D. Smith, editors. John Wiley and Sons, New York, New York, USA.

McCune, B., and T. F. H. Allen. 1985. Will similar forests develop on similar sites? Canadian Journal of Botany 63:367-376.

McGrath, M. T., S. Destefano, R. A. Riggs, L. L. Irwin, and G. J. Roloff. 2003. Spatially explicit influences on northern goshawk nesting habitat in the interior Pacific Northwest. Wildlife Society Monograph 154.

McHugh, C. W., and T. E. Kolb. 2003. Bark beetle attacks on ponderosa pine following fire in northern Arizona. Environmental Entomology 2003: 510-522.

McMillin, J. D., and K. K. Allen. 2003. Effects of Douglas-fir beetle (Coleoptera: Scolytidae) infestation on forest overstory and understory conditions in western Wyoming. Western North America Naturalist 63: 498-506.

Mellon, T. K., C. E. Meslow, and R. W. Mannan. 1992. Summertime home range and habitat use of pileated woodpeckers in western Oregon. Journal of Wildlife Management 56: 96-103.

Miller, R. S. 2001. Determining differences in the spatial distribution of forest structure on the Kaibab Plateau: implications for forest management and the northern goshawk. Master's thesis, Colorado State University, Fort Collins, Colorado, USA.

Mohren, S. R. 2002. Habitat evaluation and density estimates for the black-backed woodpecker (*Picoides arcticus*) and three-toed woodpecker (*Picoides tridactylus*) in the Black Hills National Forest. Master's thesis, University of Wyoming, Laramie, Wyoming, USA.

Morris, W., D. Doak, M. Groom, P. Kareiva, J. Fieberg, L. Gerber, P. Murphy, and D. Thomson. 1999. A practical handbook for population viability analysis. The Nature Conservancy, Arlington, Virginia, USA.

Moser, B. W., and E. O. Garton. 2004. Short-term effects of timber harvest on northern goshawk (*Accipiter gentilis*) breeding area occupancy, nest success, and productivity. Abstract, Raptor Research Foundation Annual Meeting, Bakersfield, California, USA.

Murphy, E. C., and W. A. Lehnhausen. 1998. Density and foraging ecology of woodpeckers following a stand-replacement fire. Journal of Wildlife Management 62: 1359-1372.

Nappi, A., P. Drapeau, J. Giroux, and J. L. Savard. 2003. Snag use by foraging black-backed woodpeckers (*Picoides arcticus*) in a recently burned eastern boreal forests. Auk 120: 505-511.

Nasatir, A. P. 1952. Before Lewis and Clark. Volumes 1 & 2. St. Louis Historical Documents Foundation, St. Louis, Missouri, USA.

Neuenschwander, L. F., J. W. Byler, A. E. Harvey, G. I. McDonald, D. S. Ortiz, H. L. Osborne, G. C. Snyder, and A. Zack. 1999. White pine in the American west: a vanishing species-can we save it? USDA Forest Service General Technical Report RMRS-35, Ogden, Utah, USA.
.
Newton, I. 1998. Finches. Academic Press, San Diego, California, USA.

Niemi, G. J. 1978. Breeding birds of burned and unburned areas in northern Minnesota. Loon 50: 73-84.

Nilsson, S. G. 1987. Limitation and regulation of population density in the nuthatch *Sitta europaea* (Aves) breeding in natural cavities. Journal of Animal Ecology 56: 921-937.

Oakleaf, B., B. Luce, S. Ritter, and A. Cerovski. 1992. Wyoming bird and mammal atlas. Wyoming Game and Fish Department, Lander, Wyoming, USA.

Patla, S. M. 1997. Nesting ecology and habitat of the northern goshawk in undisturbed and timber harvest areas on the Targhee National Forest, Greater Yellowstone Ecosystem. Master's thesis, Idaho State University, Pocatello, Idaho, USA.

Penteriani, V. 2002. Goshawk nesting habitat in Europe and North America: a review. Ornis Fennica 79: 149-163.

Penteriani, V., and B. Faivre. 2001. Effects of harvesting timber stands on goshawks in two European areas. Biological Conservation 101: 211-216.

Perrins, C. M. 1966. The effect of beech crops on great tit populations and movements. British Birds 59: 419-432.

Peterson, A. T., and C. R. Robins. 2003. Using ecological-niche modeling to predict barred owl invasions with implications for spotted owl conservation. Conservation Biology 17: 1161-1165.

Peterson, T. A., D. R. B. Stockwell, and D. A. Kluza. 2002. Distributional prediction based on ecological niche modeling of primary occurrence data. Pages 617-624 *in* Predicting species occurrences: issues of accuracy and scale. J. M. Scott, P. J. Heglund, M. L. Morrison, J. B. Haufler, M. G. Raphael, W. A. Wall, and F. B. Samson, editors. Island Press, Covelo, California, USA.

Pimm, S. L. 1991. The balance of nature? University of Chicago Press, Chicago, Illinois, USA.

Powell, H. D. W. 2000. The influence of prey density on post-fire habitat use of the black-backed woodpecker. Master's thesis, University of Montana, Missoula, Montana, USA.

Ralls, K., and B. L. Taylor. 1997. How viable is population viability analysis? Pages 228-235 *in* The ecological basis of conservation. S. T. A. Pickett, R. S. Ostfield, M. Shachak, and G. E. Likens, editors. Chapman and Hall, New York, New York, USA.

Ralls, K., S. R. Beissinger, and J. F. Cochrane. 2002. Guidelines for using population viability analysis in endangered-species management. Pages 521-550 *in* Population viability analysis. S. R. Beissinger, and D. R. McCullough, editors. University of Chicago Press, Chicago, Illinois, USA.

Raphael, M G., and M. White. 1984. Use if snags by cavity-nesting birds in the Sierra Nevada. Wildlife Society Monograph 86.

Redmond, R. L., M. M. Hart, J. C. Winne, W. A. Williams, P. C. Thornton, Z. Ma, C. M. Tobalske, M. M. Thornton, K. P. McLaughlin, T. P. Tady, F. B. Fisher, and S. W. Running. 1998. The Montana Gap Analysis Project: final report. Montana Cooperative Wildlife Research Unit, University of Montana, Missoula, USA.

Redmond, R. L., M. Hart, and R. Gerrard. 2001. Representing potential habitat for native terrestrial vetyebrates in Idaho and Montana: minmum sets of 7.5 quadrangles. The Montana Gap Analysis Project: unpublished report. Montana Cooperative Wildlife Research Unit, University of Montana, Missoula, USA.

Reed, J. M., D. D. Murphy, and R. F. Brussard. 1998. Efficacy of population viability analysis. Wildlife Society Bulletin 26: 244-251.

Reich, R. M., S. M. Joy, and R. T. Reynolds. 2004. Predicting the location of northern goshawk nests: modeling the spatial dependency between locations and forest structure. Ecological Modeling 176:109-133.

Renkin, R. B., and E. P. Wiggins. 1989. Forest characteristics related to pileated woodpecker territory size in Missouri. Condor 91: 642-652.

Reynolds, R. T., and B. D. Linkhart. 1987. The nesting ecology of flammulated owls in Colorado. Pages 234 to 238 *in* Biology and conservation of northern forest owls.   R. W. Nero, R. J. Clark, R. J. Knapton, and R. H. Hamre, editors. USDA Forest Service General Technical Report RM -142, Fort Collins, Colorado, USA.

Reynolds, J. T., R. T. Graham, M. H. Reiser, R. L. Bassett, P. L. Kennedy, D. A. Boyce, Jr., G. Goodwin, R. Smith, and E. L. Fisher. 1991. Management recommendations for the northern goshawk in the southwestern United States. USDA Forest Service General Technical Report RM-217, Fort Collins, Colorado, USA.

Reynolds, R. T., and B. D. Linkhart. 1992. Flammulated owls in ponderosa pine: evidence of preference for oldgrowth. Pages 166-169 *in* Old-growth forests in the southwest and Rocky Mountains Regions: proceedings of a workshop. USDA Forest Service General Technical Report RM-213, Fort Collins, Colorado, USA.

Rickletts, T. H., E. Dinnerstein, D. M. Olsen, C. J. Louks, W. Eichbaum, D. DellaSalla, K. Kavanagh, P. Hedo, P. T. Hurley, K. M. Carney, R. Abell, and S. Waters. 1999. Terrestrial ecoregions of North America. Island Press, Covelo, California, and Washington, DC, USA.

Rockwell, F. J. 1917. Western white pine. Part 1. The tree and the stand. Unpublished inventory on file. Idaho Panhandle National Forests, Coeur d' Alene, Idaho, USA.

Rollins, M. and T. W. Swetnam, and P. Morgan. 2000. Pages 283-287 *in* Twentieth century fire patterns in the Gila/Aldo Leopold Wilderness Complex New Mexico and the Selway-Bitterroot Wilderness Area Idaho/Montana. D. N. Cole, S. F. McCool, W. T. Borrie, and J. O'Loughlin, compilers. Wilderness science in a time of change conference - Volume 5: wilderness ecosystems, threats and management. USDA Forest Service Rocky Mountain Research Station, Proceedings RMRS-P-15-VOL-5.

Saab, V. A., and J. G. Dudley. 1998. Responses of cavity-nesting birds to stand replacement fire and salvage logging in ponderosa pine/Douglas-fir forests of Southwestern Idaho. USDA Forest Service Research Paper RP-11, Boise, Idaho, USA.

Salwasser, H., S. P. Mealey, and K. Johnson. 1984. Wildlife viability: a question of risk. Transactions of the North American Wildlife and Natural Resources Conference. 49: 421-421.

Samson, F. B. 1983. Minimum viable populations: a review. Natural Areas Journal 3: 15-23.

Samson, F. B. 2002. Population viability analysis: management, and conservation planning at large scales. Pages 425-441 *in* Population viability analysis. S. R. Beissinger, and D. R. McCullough, editors. University of Chicago Press, Chicago, Illinois, USA.

Samson, F. B., F. Perez-Trejo, H. Salwasser, L. F. Ruggiero, and M. L. Shaffer. 1985. On determining and managing minimum population size. Wildlife Society Bulletin 13: 425-433.

Samson, F. B., and F. L. Knopf. 1996a. Putting “ecosystem” into natural resource management. Journal of Soil and Water Conservation July-August: 288-291.

Samson, F. B., and F. L. Knopf. 1996b. Prairie Conservation: Preserving North America's most endangered ecosystem. Island Press, Washington, DC, USA.

Samson, F. B., F. L. Knopf, C. L. McCarthy; W. R. Ostlie, S. Larson, G. E. Plumb, B. R. Noon, D. N. Svingen, G. L. Schenbeck, S. M. Rinehart, and T. W. Byer. 2003. Conservation planning for population viability on Forest Service lands in the northern Great Plains USA. The Wildlife Society Bulletin 31: 986-999.

Samson, F. B. , F. L. Knopf, and W. R. Ostlie. 2004. Great Plains ecosystems: past, present and future. Wildlife Society Bulletin 32: 6-15.

Sancez-Martinez, G., and M. R. Wagner. 2002. Bark beetle community structure under four ponderosa pine stand conditions in northern Arizona. Forest Ecology and Management 170: 145-160.

Schoenagel, T., T. T. Veblen, and W. H. Romme. 2004. The interaction of fires, fuels, and climate across Rocky Mountain forests. BioScience 54: 661-675.

Sergio, F., and I. Newton. 2003. Occupancy as a measure of territorial quality. Journal of Animal Ecology 72: 857-865.

Setterington, M., I. D. Thompson, and W. A. Montevecchi. 2000. Woodpecker abundance and habitat use in mature balsam fir forests in Newfoundland. Journal of Wildlife Management 64: 335-345.

Shackelford, C. E., and R. N. Connor. 1997. Woodpecker abundance and habitat use in three forest types in eastern Texas. Wilson Bulletin 109: 132-141.

Shaffer, M. L. 1981. Minimum population sizes for species conservation. BioScience 31: 131-134.

Shaffer, M. L., and F. B. Samson. 1985. Population size and extinction: a note on determining critical population size. American Naturalist 125: 144-152.

Shaffer, M. L., L. H. Watchman, W. J. Snape III, and I. K. Latchis. 2002. Population viability analysis and conservation policy. Pages 123-145 *in* Population viability analysis. S. R. Beissinger, and D. R. McCullough, editors. University of Chicago, Chicago, Illinois, USA.

Short, L. L. 1971. Systematics and behavior of some North American woodpeckers, genus Picoides. Bulletin of the American Museum of Natural History 145: 1-118.

Short, L. L. 1974. Habitats and interactions of North American three-toed woodpeckers (*Picoides arcticus* and *Picoides tridactylus*). American Museum Novitates 2547: 1-42.

Small, A. 1994. California birds: their status and distribution. Ibis Publishing Company, Vista, California, USA.

Smith, J. K., and W. C. Fischer. 1997. Fire ecology of the forest habitat types of northern Idaho. USDA Forest Service General Technical Report INT-363, Ogden, Utah, USA.

Sonsthagen, S. A. 2002. Year-round habitat, movement, gene flow of northern goshawks breeding in Utah. Master's thesis. Brigham Young University, Provo, Utah, USA.

Squires, J. R., and L. F. Ruggiero. 1995. Winter movements of adult northern goshawks that nested in southcentral Wyoming. Journal of Raptor Research 29: 5-9.

Squires, J. R., and R. T. Reynolds. 1997. Northern Goshawk. No. 298. In The birds of North America. The Academy of Natural Sciences, Philadelphia, Pennsylvania, and The American Ornithologists' Union, Washington, DC, USA.

Stephens, R. M. 2001. Migration, habitat use, and diet of northern goshawks (*Accipiter gentilis*) that winter in the Uinta Mountains, Utah. Master's thesis, University of Wyoming, Laramie, Wyoming, USA.

Taylor, D. L. 1979. Forest fires and tree-hole nesting cycle in Grand Teton and Yellowstone National Parks. Transactions of the First Science and Research Conference 1: 509-511.

Taylor, D. L., and W. J. Barmore, Jr. 1980. Post-fire succession of avifauna in coniferous forests of Yellowstone and Grand Teton National Parks, Wyoming. Pages 130-145 *in* Management of western forests and grasslands for non game birds. USDA Forest Service General Technical Report INT-86, Ogden, Utah, USA.

Taylor, J., and E. Schachtell. 2002. Black-backed woodpecker habitat analysis of six Idaho Panhandle National Forest at two scales. Unpublished mimeo on file, Idaho Panhandle National Forests, Coeur d' Alene, Idaho, USA.

Thomas, J. W., E. D. Forsman, J. B. Lint, E. C. Meslow, B. R. Noon, and J. Verner. 1990. A conservation strategy for the northern spotted owl: a report of the Interagency Scientific Committee to address the conservation of the northern spotted owl. USDA Forest Service; USDI Bureau of Land Management, Fish and Wildlife Service, National Park Service. Portland, Oregon, USA.

Thompson, I. D., H. A. Hogan, and W. A. Montevecchi. 1999. Avian communities of mature balsam forests in Newfoundland: age-dependence and implications for timber harvest. Condor 99: 311-323.

USDI Fish and Wildlife Service. 1998. Status review of the northern goshawk in the forested west. Portland, Oregon, USA.

Van Tyne, J. 1926. An unusual flight of Arctic three-toed woodpeckers. Auk 43: 469-474.

Villard, P. 1994. Foraging behavior of black-backed and three-toed woodpeckers during spring and summer in a Canadian boreal forest. Canadian Journal of Zoology 72: 1957-1959.

Villard, P., and C. W. Beninger. 1993. Foraging behavior of male black-backed and hairy woodpeckers in a forest burn. Journal of Field Ornithology 64: 71-76.

Wallin, K. F., T. E. Kolb, K. R. Skov, and M. R. Wagner. 2003. Effects of crown scorch on ponderosa pine resistance to bark beetles in northern Arizona. Environmental Entomology 32: 652-661.

Weinhagen, A. C. 1998. Nest-site selection by the black-backed woodpecker in northeast Vermont. Master's thesis, University of Vermont Burlington, Vermont, USA.

Werner, R. A. 2002. Effect of ecosystem disturbance on diversity of bark and wood-boring beetles. USDA Forest Service Research Paper PNW-546, Portland, Oregon, USA.

Werner, R. A., and K. E. Post. 1985. Effects of wood-boring insects and bark beetles on survival and growth of burned white-spruce. Pages 14-16 *in* Early results of the Rosie Creek fire research project-1984. Agricultural Experiment Station Publication 85-2, University of Alaska, Fairbanks, Alaska, USA.

West, J. D., and J. M. Speirs. 1959. The 1956-1957 invasion of three-toed woodpeckers. Wilson Bulletin 71: 348-363.

Whitford, T. 1991. Defining old-growth Douglas-fir forests of central Montana and use of the Northern Goshawk (*Accipiter gentilis*) as a management indicator. Master's thesis, University of Montana, Missoula, Montana, USA.

Wickman, B. E. 1965. Black-backed Three-toed Woodpecker, *Picoides arcticus*, predation on *Monochamus oregonensis* (Coleoptera: Cerambycidae). Pan-pacific Entomology 41: 162-164.

Winter, J. 1974. The distribution of the flammulated owl in California. Western Birds 5: 25-43.

Wouldenberg, A. M. van. 2003. Estimating flammulated owl population trends at the northern range limit. Bird Trends Winter: 45-47.

Woudenberg, A. M. van, and D. A. Christie. 2000. Flammulated owl habitat model validation for the Merrit and Kamloops Forest Districts. Proceedings of a conference on the biology and management of species and habitats at risk, Kamloops, British Columbia. British Columbia Ministry of Environment, Lands and Parks, Victoria, British Columbia, Canada.

Wright, V. 1996. Multi-scale analysis of flammulated owl habitat use: owl distribution, habitat management, and conservation. Master's thesis, University of Montana, Missoula, Montana, USA.

Yunick, R. P. 1985. A review of recent irruptions of the black-backed woodpecker and three-toed woodpecker in eastern North America. Journal of Field Ornithology 56:138-152.

Zack, A. C. 1994. Early succession in western hemlock habitat types of northern Idaho. Dissertation, University of Idaho, Moscow, Idaho, USA.

Zwickel, F. C., and M. A. Schroeder. 2003. Grouse of the Lewis and Clark expedition. Northwest Science 84: 1-19.

Appendix 1

Estimating Minimum Viable Population Numbers

Minimum viable population numbers have rarely been estimated directly (Saether and Engen 2002) or, in a meaningful manner, by the use of quantitative models (Beissinger and Westphal 1998, Beissinger and McCullough 2002, Ralls et al. 2002, Shaffer et al. 2002, Perry et al. 2004, and others).

The inability to estimate or use quantitative models to estimate minimum viable population numbers is based on three primary factors.

1. The quality of available demographic, population, or spatially explicit data, often poor and short-term in nature, results in large sampling errors and wide variance in model parameters (Beissinger and Westphal 1998, Morris et al. 1999, and others). Therefore, minimum viable population numbers based on such models exhibit both a wide variance and lack of reality (Ludwig and Walters 2002).

2. Stochasticity (Shaffer and Samson 1985), either demographic or environmental, is suggested to influence the dynamics of small populations. Demographic or environmental stochasticity, as described later, are difficult to model (Beissinger and Westphal 1998). Moreover, although regularly incorporated into population projection models, empirical evidence as to the role of either demographic or environmental stochasticity in population extinction is missing. Very important is the fact that the decision to incoporate stochasticity in a population projection model can have a large influence on the size of subsequent and model-based minimum population size projections (Groom and Rascal 1998).

3. Even in simple population projection models, small variation in key model parameters can lead to large variation in estimates of minimum viable population numbers (Ginzburg et al. 1990). Clearly, even in considering the observer error in collecting data, "we must either know there is very little observation error or, more releastically, have some estimate of this source of variation" (Morris et al. 1999: 67).

The following is a brief review of the published references that focus on the three primary limitations in the use of any quantitative model to estimate minimum viable popluation numbers—1) models and lack of data, 2) incoporating stochasicity, and 3) the influence of small changes in input variables to a minimum viable population number model. This is not intended to be a complete review of the literature nor a detailed critique.

Models

Models are common approaches to estimate minimum viable population numbers including demographic (simple deterministic single-population, stochastic single-population models, and metapopulation), genetic, and algometric scaling.

Demographic models. Beissinger and Westphal (1998) provided concise and clear guidelines to enable use of deterministic single-population models, stochastic-single population models, and metapopulation models (Table 1, page 824) to estimate minimum viable population numbers.

In general, deterministic single-population models are usually based on a matrix which permits calculating change over time for a particular age or structure class (Beissinger and Westphal 1998: 821). Data required for deterministic single-population models Beissinger and Westphal 1998: 824, Table 1) include age or stage structure, age of first breeding, mean fecundity for each age or stage, and mean survival for each age or stage.

Demographic stochasticity as a component on a minimum viable population model includes the assumption that demographic rates change randomly at each time step. For a stochastic single-population model, demographic data required include age or stage structure, age of first breeding, mean fecundity for each age or stage, mean survival for each age or stage, variance in fecundity, variance in survival, carrying capacity and density dependence (Beissinger and Westphal 1998: 824, Table 1).

Environmental stochasticity in concept is when an environmental factor such as weather, fire, and so on that may have an unpredictable or random effect on a population. When included in a single-population stochastic simulation model, demographic and environmental data that must be included are age or stage structure, age of first breeding, mean fecundity for each age or stage, mean survival for each age or stage, variance in fecundity, variance in survival, carrying capacity and density dependence, variance in carrying capacity, frequency and magnitudes of catastrophes, covariance in demographic rates, and spatial covariance in rates (Beissinger and Westphal 1998: 824, Table 1).
.
A metapopulation is described by the following conditions: "there has to be discrete habitat patches which are, or can be, inhabited by breeding subpopulations" (Elmhagen and Angerbjorn 2001: 89) where

1) all patch-specific subpopulations have a risk to extinction,

2) empty habitat patches can be colonized,

3) population dynamics of patch-specific subpopulations have to be asynchronous, and

4) simultaneous extinction of all patch-specific subpopulations is unlikely.

For a metapopulation model (Beissinger and Westphal 1998: 824, Table 1), demographic and landscape data are required. Demographic data include age or stage structure, age of first breeding, mean fecundity for each age or stage, mean survival for each age or stage, variance in fecundity, variance in survival, carrying capacity and density dependence, variance in carrying capacity, frequency and magnitudes of catastrophes, covariance in demographic rates, and spatial covariance in rates. Landscape data include patch types, distance between patches, and area of patches.

If the a metapopulation model is spatially explicit, then space-specific demographic, landscape, and dispersal information is required (Beissinger and Westphal 1998: 824, Table 1). Required demographic information includes age or stage structure, age of first breeding, mean fecundity for each age or stage, mean survival for each age or stage, variance in fecundity, variance in survival, carrying capacity and density dependence, variance in carrying capacity, frequency and magnitudes of catastrophes, covariance in demographic rates, and spatial covariance in rates. Required landscape data include patch types, distance between patches, and area of patches. Required dspersal data include number in dispersing age class or classes, timing of dispersal, dispersal-related mortality, number immigrating, and movement rules.

A further complication in estimating a minimum viable number for a metapopulation is the interaction of the spatially explicit factors (age or stage structure, age of first breeding, mean fecundity for each age or stage, mean survival for each age or stage, variance in fecundity, variance in survival, carrying capacity and density dependence, variance in carrying capacity, frequency and magnitudes of catastrophes, covariance in demographic rates, and spatial covariance in rates), the landscape (patch types, distance between patches, and area of patches), dispersal (number dispersing age class and timing of dispersal, dispersal-related mortality, number immigrating, and movement rules) and habitat change (Amarasekare and Possingham 2001).

Available metapopulation models do not consider effects of habitat change whether in habitat quality, alteration to habitat quality, changes in interpatch distances, vegetation succession, and other environmental variables that might influence estimating minimum viable population numbers, making their application unrealistic.

The lack of quality of available demographic, population, and or spatially explicit data (problem 1 in estimating minimum viable population numbers) and how small variation in key model parameters can lead to large variation in estimates of minimum viable population numbers (problem 3 in estimating minimum viable population numbers) is illustrated in a case history—the Florida panther, an endangered species.

Maehr et al. (2002) desribe four well-intended model-based conservation efforts to estimate either the time tro extinction or the estimated Florida panther (*Puma concolor coryi*) population number at the end of an arbitary time period (100 years in this case).

The 1989 model based effort suggested Florida panther population extinction in 23.1 years. The 1992 model projection predicted Florida panther population extinction in 43.7 years. A second 1992 "consensus" model-based estimate was to have 47.4 Florida panthers to be alive at the end of the 100 years.

In 1999, four "experts" representing either a state conservation agency, a federal conservation agency, or university and all with access to peer-reviewed professional society literature were asked for input to establish required minimum viable population model parameters (Maehr et al. 2002). The four "experts," used VORTEX, a readily available and commercial software, to estimate either time of extinction or number of Florida panthers predicted to be alive at the end of a 100 year simulation interval. This four "expert" and model-based effort suggested 65.7 panthers at the end of 100 years.

Overall, the four "quantitative" model-based estimates for the Florida panther population range from extinction in 23.1 years to having 65.7 panthers at the end of 100 years. Differences in the four minimum viable population number estimates "were primarily due to the use of fewer guesses (by experts) in model inputs" (Maehr et al. 2002: 305). Other examples exist as to 1) the importance of long-term data (see also Morris et al. 1999: pages 15, 16, and 29: "*We recommend ten censuses be viewed as the absolute minimum*" (the author's italics) and, 2) the futility in use of "expert" opinion as the basis to estimate minimum viable population numbers.

Stochasticity (Shaffer and Samson 1985), either demographic or environmental, is suggested to influence the dynamics of small populations and, therefore, their time to extinction.

In 1985, Shaffer and Samson introduced stochasticity as an element to include in estimating a viable population number. This contribution in the *American Naturalist* was based on a classroom exercise. The intent was twofold:

> 1) to correct minimum viable population for the grizzly bear in Shaffer's 1981 (1981) seminal article on minimum viability populations (i.e., 10 bears); and
>
> 2) to suggest stochasticity was a concept to consider in understanding population viability.

The article as published was not intended to be the basis for a species recovery plan as required under the Endangered Species Act (1973).

A recent review of the peer-reviewed professional society literature found no published study with empirical support for either demographic or environmental stochasticity as a factor in causing an extinction of a species (models, yes, but not empirical evidence).

Several well-document studies do clearly demonstrate that environmental and demographic stochasticity do play a significant role at edges of species distributions. Rodriguez (2002) in a review of North American bird population declines demonstrates that, given the normal bell-shaped pattern in abundance for species (i.e., common in the center of the distribution, more rare on the periphery), conservation (core or other conservation area) should

> 1) focus on the center of a species' distribution (where the species is abundant), and
>
> 2) populations near the periphery of their respective distributions are expected to "wink" out-and-in given the influences of weather and other factors (see Brown 1995, Figure 4, page 56 for further information).

Wilcove et al. (1998) summarized factors that place species at-risk that are listed under the Endangered Species Act (1973) in the United States. Habitat loss, invasive species, and human/recreation activities are the primary factors. Evidence for the role of either demographic or environmental causing an extinction of a species is absent.

Model-based estimates that include either demographic or environmental data hould be viewed with considerable caution until field/empirical evidence is provided as to their effect on species extinction. Empirical validation of models that include stochasticity to estimate minimum viable population numbers would require tracking scores of replicate populations that experience similar conditions and comparing predicted to observed frequencies of extinction (Beissinger and Westphal 1998).

Genetic models. The recommendation of a net effective population equal to 50 individuals is regarded "as a general minimum requirement for short-term conservation" (Allendorf and Ryman 2002: 76). These authors point out, however, that generation interval is an important consideration.

An isolated net effective population of 50 with a generation interval of more than twenty years will maintain 95% of initial heterozygosity after 100 years. An isolated population with a generation length of two years will require a net effective population of upwards to 600 individuals (Figure 4.1, page 66, Allendorf and Ryman 2002) in order to maintain 95% of initial heterozygosity after 100 years.

The current disagreement among geneticists regarding size of net effective population in order to maintain genetic variation will most likely continue (Allendorf and Ryman 2002). In the interim, a "global" population with the opportunity to exchange genetic material of 500 to 1,000 individuals capable of breeding is considered a long-term goal (page 76). Estimates of short-term population genetic-based minimum viable population goals are increasingly few, given the long-tern nature of genetic change and the ability of a single immigrant to a population to reduce the effects of inbreeding in small populations.

Allometric scaling. Many reports of the strong relationship of species-specific body mass and home range/territory size are available, e.g., Holling 1992, Brown 1995, and others; and, in general, this is referred to as allometric scaling.

In simple terms, small-bodied species have small home ranges while large bodied species tend to have large home ranges. Several authors including Diniz-Filho et al. (2005) show how the allometric relationship relates to conservation, specifically for mammalian carnivores.

Silva and Downing (1994) were among the first conservationists to provide specific conservation recommendations using allometric scaling and the minimal densities required to conserve species (mammalian carnivores in this case).

Smallwood (2001:103), in her review of 83 published studies of mammalian carnivores, stated her objectives among others to be 1) "identify the range of study areas within which intra-specific abundance estimates represent the typical population," 2) "estimate the size of population characteristic of each species," and 3) "predict the areas of high quality habitat needed to support populations of terrestrial mammalian carnivores" using the allometric relationships (e.g., minimum space occupied by a population, body size, home range size, and so on).

As published, Table 2 in Smallwood (2000) provides the basis to estimate the threshold area to conserve mammalian carnivores. This, in turn, could be used to provide an estimate of minimum viable numbers for species of mammalian carnivore in North America, considering the field-based and species-specific estimates of home range size,.

Real studies

A second and non-model approach to determinine minimum viable population numbers is to consider real studies. Unfortunately, few real studies exist as to the causes of extinction (Beissinger and Westphal 1998, Perry et al. 2004).

A number of widely cited case histories have shown small populations do not necessarily lead to extinction, e.g., the northern elephant seal (*Mirounga angustirostris*) recovered from about 20 individuals to a population of at least 30,000 individuals in a period of 75 years (Bonnell and Selander 1974). In studies of island birds, Jones and Diamond (1974) have shown isolated populations with a median of less than 10 pairs have survived for upwards to 80 years. Bird populations of 200 are known to have a high probability of survival for a similar (75 year) interval (Thomas 1990).

Thomas (1990: 327) in an article *What do real population dynamics tell us about minimum viable population sizes?* suggested, "When populations show average or low population variability and inhabit stable environments, geometric mean values of 500 may be adequate for long-term persistence" and 100 for short-term persistence for a large-bodied species with relatively stable birth and death rates. Such estimates of minimum viable population number are similar to that provided by Weilgus (2002) for the large-bodied grizzly bear (*Ursus arctos*) (i.e., a minimum number of 250), based on a compilation of six different grizzly bear studies. Such collective reviews of studies may represent a general rule-of-thumb, i.e., a global population for large-bodied species of >250 is adequate to maintain persistence.

For small-bodied species, based on real studies, and at least in the short term, e.g., 100 years, numbers of = or >1,000 (Allendorf and Ryman 2002 and others) appear to be required to maintain a global population although populations with much smaller numbers have been known to recover.

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Factors to consider

1. Nearly all available model-based estimates minimum viable population numbers do so to provide that number needed to maintain a "global" population. A global population is comprised of all individuals capable to reproduce and independent of any administrative or other border.

Public lands, including those managed by the Forest Service, may only include relatively small areas of habitat important to a particular species and that provide for the global population. In other words, public lands may contribute within their capability to that required to maintain a global population (250 to >1,000 depending on body size and life history traits), but public lands cannot be expected to support a global population for each and every species.

2. Another major challenge in predicting a minimum viable population number is that "predicting the future is difficult, especially if the prediction concerns a long time span, say 100 years" and "such predictions typically assume a constant environment or are based on wild guesses on how much the environment might change" (Hanski 2002: 100).

Ludwig and Walters (2002: 516) compared model-based estimation of a minimum viable population number to model-based weather forecasting, something of great practical importance, "yet we must recognize that they are not very accurate and cannot probably be made more accurate."

3. Clearly, "Models have been used to diagnose causes of population decline (Crouse et al. 1987, Doak et al. 1994, and others) but need to be interpreted *very* cautiously" (Beissinger and Westphal 1998: 834). Yet current "demographic PVAs (population viability analyses) are not currently capable of forecasting when species go extinct" (Beissinger and Westphal 1998: 836). Such models cannot be substituted for field studies or for the consideration of approaches that focus on habitat—the primary factor in the persistence of species (Boyce 1992).

In the nearly 25 years the science of estimating viable populations has existed, quantitative models (and their model-based numerical estimates) have made few meaningful contributions to the science of population viability and clearly should be replaced by widely agreed to and habitat-based ecological principles until longterm demographic, population, and genetic information is available (Shaffer et al. 2002).

Literature Cited

Allendorf, F. W., and N. Ryman. 2002. The role of genetics in population viability. Pages 50-85 *in* Population viability analysis. S. R. Beissinger, and D. R. McCullough, editors. University of Chicago Press, Chicago, Illinois, USA.

Amarasekare, P, and H. Possingham. 2001. Patch dynamics and metapopulation theory: the case of successional species. Journal of theoretical biology 209: 333-44.
Beissinger, S. R., and D. R. McCullough. Population viability analysis. University of Chicago Press, Chicago, Illinois, USA.

Beissinger, S. R., and M. I. Westphal. 1998. On the use of demographic models of population viability in endangered species management. Journal of Wildlife Management 62:821-841.

Bonnel, M. L., and R. K. Selander. 1974. Elephant seals: genetic variation and near extinction. Science 184: 908-909.

Boyce, M. S. 1992. Population viability analysis. Annual Review of Ecology and Systematics 23: 481-506.

Brown, J. H. 1995. Macroecology. University of Chicago Press, Chicago, Illinois, USA.

Crowder, L. B., D. T. Crouse, S. S. Heppell, and T. H. Martin. 1994. A stage-based population model for loggerhead sea turtles and implications for conservation. Ecology 68: 1412-1423.

Diniz-Filho, J. A. F., P. Carvalho, L. M. Bini, and N. M. Torres. 2005. Macroecology, geographic range size-body size relationship and minimum viable population analysis for New World carnivora. Acta Oecologica 27: 25-30.

Doak, D., P. Kareiva, and B. Klepetka. 1994. Modeling population viability for the desert tortise in the western Mojave Desert. Ecological Applications 4: 446-460.

Elmhagen, B., and A. Angerbjorn. 2001. The applicability of metapopulation theory to large mammals. Oikos 94: 89-100.

Ginzburg, L. R., S. Ferson, and H. R. Akcakaya. 1990. Reconstructability of density dependence and the conservative assessment of extinction risks. Conservation Biology 4: 63-70.

Groom, M. J., and M. A. Pascal. 1998. The analysis of population persistence: an outlook on the practice of viability analysis. Pages 4-27 in P. L. Fiedler, and P. M. Kareiva, editors. Conservation Biology. Chapman & Hall, New York, New York, USA.

Hanski, I. 2002. Metapopulations of animals in highly fragmented landscapes and population viability analysis. Pages 86-108 *in* Population viability analysis. S. R. Beissinger, and D. R. McCullough, editors. University of Chicago Press, Chicago, Illinois, USA.

Holling, C. S. 1992. Cross-scale morphology, geometry, and dynamics of ecosystems. Ecological Monographs 62: 447-502.

Jones, H. L., and J. M. Diamond. 1976. Short-time-base studies of turnover in breeding birds on the California Channel Islands. Condor 78: 526-549.

Ludwig, D., and C. J. Walters. 2002. Fitting population viability analysis into adaptive management. Pages 511-520 *in* Population viability analysis. S. R. Beissinger, and D. R. McCullough, editors. University of Chicago Press, Chicago, Illinois, USA.

Maehr, D. S., R. C. Lacey, E. D. Land, O. L. Bass Jr., and T. S. Hoctor. 2002. Evolution of population viability assessments for the Florida panther: a multiperspective approach. Pages 282-311 *in* Population viability analysis. S. R. Beissinger, and D. R. McCullough, editors. University of Chicago Press, Chicago, Illinois, USA.

Morris, W., D. Doak, M. Groom, P. Kareiva, J. Fieberg, L. Gerber, P. Murphy, and D. Thomson. 1999. A practical handbook for population viability analysis. The Nature Conservancy, Arlington, Virginia, USA.

Perry, M. Z., S. R. Beissinger, S. H. Newman, E. B. Burkett, and T. D. Williams. 2004. Applying the declining population paradigm: diagnosing causes of low reproductive success in Marbled Murrelets. Conservation Biology 18: 1088-1098.

Ralls, K., S. R. Beissinger, and J. F. Cochrane. 2002. Guidelines for using population viability analysis in endangered-species management. Pages 521-550 *in* Population viability analysis. S. R. Beissinger, and D. R. McCullough, editors. University of Chicago Press, Chicago, Illinois, USA.

Rodriguez, JP. 2002. Range contraction in declining North American bird populations. Ecological Applications 12: 238-248

Sather, B., and S. Engen. 2002. Including uncertainties in population viability analysis using population prediction intervals. Pages 191-212 *in* Population viability analysis. S. R. Beissinger, and D. R. McCullough, editors. University of Chicago Press, Chicago, Illinois, USA.

Shaffer, M. L. 1981. Minimum population sizes for species conservation. BioScience 31: 131-134.

Shaffer, M. L., and F. B. Samson. 1985. Population size and extinction: a note on determining critical population size. American Naturalist 125: 144-152.

Shaffer, M., L. H. Watchman, W. J. Snape III, and I. K. Lathis. 2002. Population viability analysis and conservation policy. Pages 123-142 *in* Population viability analysis. S. R. Beissinger, and D. R. McCullough, editors. University of Chicago Press, Chicago, Illinois, USA.

Silva, M., and J. Downing. 1994. Allometric scaling of minimal mammal densities. Conservation Biology 8: 732- 743.

Smallwood, K. S. 2001. Scale domains of abundance amongst species of mammalian Carnivora. Environmental Management 26: 102-111.

Thomas, C. D. 1990. What do real populations tell us about minimum viable population sizes. Conservation Biology 4: 324-327.

Wielgus, R B. 2002. Minimum viable population and reserve sizes for naturally regulated grizzly bears in British Columbia. Biological Conservation 106: 381-388.

Appendix 2

Bootstrap Approach

Bootstrap Calculation of Confidence Intervals for the Estimates of Means by Stratum

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What is Bootstrap?

Bootstrap is a non-parametric method that can be used for calculating the confidence of estimates. Being non-parametric means that the bootstrap method does not make assumptions about the underlying distribution of the data such as independence and normality—two common assumptions of other techniques such as simple linear regression. This is particularly useful in plot data such as FIA where the correlation structure among plots and subplots is very complicated.

How The Bootstrap Works

The bootstrap works by essentially simulating the variability of the data. That is to say it creates random realizations of the data by sampling the data with replacement. For FIA data such as those plots installed on the Idaho Panhandle National Forest where the plot design consisted of 4 subplots per plot, this means selecting plots randomly with replacement, and then within each plot selecting four subplots randomly with replacement (e.g. it is possible to select the same plot more than once and within each plot it is possible to select the same subplot more than once). If a plot was designed to have 4 subplots but only three were actually measured then the fourth plot is considered a missing value and included in the resampling. For plot data, there are two components of variability that contribute to the uncertainty of the estimate of the statistic of interest: within plot variability and between plot variability. To get the best confidence interval for the statistic of interest it is important to simulate both components of variability. That is why the subplots are included in the random realization process, and not just the mean of the subplot values.

For each random realization of the data the statistic of interest is calculated (in many cases the statistic is the mean, but it could be anything). Many random realizations (typically on the order of 40,000) produce many point estimates of the statistic of interest. These are ordered from smallest to largest. The $100*(\alpha /2)^{th}$ percentile is the $100*(1-\alpha)\%$ confidence interval lower bound and the $100*(1-\alpha /2)^{th}$ percentile is the $100*(1-\alpha)\%$ confidence interval upper bound. In this context α is one minus the confidence level (so for a 90% confidence interval $\alpha = 0.10$). For example, if 40,000 bootstrap iterations were performed and a 90% confidence interval is desired the lower bound is the 2,000th largest point estimate and the upper bound is the 38,000th largest point estimate (40,000*(0.1/2) and 40,000*(1-0.1/2) respectively). The standard error of the estimate of the statistic of interest is also calculated. It is the standard deviation of the estimates of the statistics of interest from the bootstrap iterations.

When strata are introduced, the algorithm changes only slightly. Suppose there are k strata. Each plot is assigned to a stratum. This means that all the subplots belonging to a plot are assigned to the same stratum. Assigning the stratum at the plot level is necessary to accommodate the calculation of the statistic of interest. The statistic of interest is calculated on a per plot basis to correctly simulate the variability structure of the data: the subplot is a subsample of the plot (primary sampling unit). For each bootstrap iteration the statistic of interest is calculated for each stratum using only the plots from the random realization that fall within that stratum. Thus a bootstrap of 40,000 iterations will result in k sets of 40,000 point estimates of the statistic of interest. Each of these is then ordered from smallest to largest and the appropriate percentiles become the lower and upper bound for the confidence interval of the statistic of interest for each of the strata. The standard error is calculated similarly for each stratum.

For precise details of how the bootstrap is performed refer to the section of this document labeled Bootstrap Algorithm Details.

Interpreting The Results

The bootstrap algorithm results in a standard error, confidence interval lower bound, point estimate, and confidence interval upper bound for the statistic of interest and for each stratum. Note that the point estimate of the statistic of interest is just the statistic calculated from the dataset—no bootstrap iterations are required to generate this. The proper interpretation of the confidence interval is "if a new random realization of the data was collected its statistic would have a 1-α probability of being contained by the interval." Or in other word if the experiment was performed 100 more it is expected that the point estimate will be contained in the interval 100*(1-α)% of the time.

The standard error is also a useful measure of the precision of the estimate. Essentially the standard error is the standard deviation of the estimate of the mean. Clearly, when the standard error is large the precision in the estimate of the statistic of interest is not very good. The standard error can also be used to form a crude approximation of the confidence interval. It can be reasonably assumed that the true value of the parameter falls within +/- two standard errors of the point estimate. This is not necessary in the case however because bootstrap confidence intervals are much better.

Bootstrap Algorithm Details

This is a precise description of how the bootstrap algorithm is performed. Let n be the number of observed plots and m_i be the number of subplot observations for the ith plot. This results in the sequence of observations $\left\{\left\{y_{ij}\right\}_{j=1}^{m_i}\right\}_{i=1}^{n}$. Also for any stratification, let k be the number of strata.

1. Resample n plots from $\{y_i\}_{i=1}^{n}$, with replacement to obtain $\{y_i^*\}_{i=1}^{n}$.
2. Resample m_i units with replacement within the ith plot obtained in step1 to get $y_i^{**} = \left(y_{i1}^{**}, y_{i2}^{**}, \ldots, y_{im_i^*}^{**}\right)$. Usually for plot data there should be a fixed number of subplots per plot, e.g. $m_i = m$ for all i. However, some of these values may be missing so there might only be $0 \le m_i^* \le m_i$ subplots for the i^{th} bootstrapped plot.
3. Repeat step 2 for all $\{y_i\}_{i=1}^{n}$.
4. Let $\hat{\theta}_S^{\ **} = \hat{\theta}\left(y_{11}^{**}, y_{12}^{**}, \ldots, y_{1m_1}^{**}, \ldots, y_{n1}^{**}, \ldots, y_{nm_n}^{**}\right)$ be the statistic of interest for stratum S. For this study the statistic of interest is the mean: $\hat{\theta}_S\left(y_{11}^{**}, y_{12}^{**}, \ldots, y_{1m_1}^{**}, \ldots, y_{n1}^{**}, \ldots, y_{nm_n}^{**}\right) = \left(\sum_{i=1}^{n} I\left(y_i^* \in S\right)\right)^{-1}\left(\sum_{y_i^* \in S}\sum_{j=1}^{m_i^*}\frac{y_{ij}^{**}}{m_i^*}\right)$ where $I(\ )$ is the indicator function, e.g. $I\left(y_i^* \in S\right) = 1$ if $y_i^* \in S$ and $I\left(y_i^* \in S\right) = 0$ if $y_i^* \notin S$. All subplots from a single plot fall in the same stratum, e.g. if $y_i^* \in S$ then $y_{ij}^{**} \in S$ for $j = 1, \ldots, m_i$.
5. Repeat step 4 for all strata $S = 1, \ldots, k$.
6. Repeat steps 1-5 a large number of times, $B = 40000$, to obtain $\hat{\theta}_{S1}^{**}, \hat{\theta}_{S2}^{**}, \ldots, \hat{\theta}_{SB}^{**}$ for $S = 1, \ldots, k$. To obtain the $100*(1-\alpha)\%$ confidence interval for strata S, order $\hat{\theta}_{S1}^{**}, \hat{\theta}_{S2}^{**}, \ldots, \hat{\theta}_{SB}^{**}$ from smallest to largest. The $100*(1-\alpha)\%$ confidence interval lower bound is the $100*(\alpha/2)^{\text{th}}$ percentile and the $100*(1-\alpha/2)^{\text{th}}$ percentile is the $100*(1-\alpha)\%$ confidence interval upper bound for the estimate in stratum S. To obtain the standard error simply calculate the standard deviation of $\hat{\theta}_{S1}^{**}, \hat{\theta}_{S2}^{**}, \ldots, \hat{\theta}_{SB}^{**}$, namely $SE_S = \sqrt{\frac{1}{B-1}\sum_{i=1}^{B}\left(\hat{\theta}_{Si}^{**} - \frac{1}{B}\sum_{j=1}^{B}\hat{\theta}_{Sj}^{**}\right)^2}$. Compute confidence intervals and standard errors in this manner for all strata $S = 1, \ldots, k$.

Appendix 3

Bootstrap Results

The species- and area-specific habitat estimates that follow are estimated by the bootstrap methodology. The Standard Error (SE) describes the variability of the estimate of the mean. The intensive resampling (or bootstrap method) for evaluating the properties of estimates is based on 40,000 resamples. The interpretation is that one should be confident that the mean value for an estimate will be within plus or minus one SE.

Regional models

Northern goshawk nest habitat

Strata	Category	Standard Error	CI Low	Estimate	CI High	Habitat Subplots	EstimateSubplots
02	Beaverhead Deerlodge	9.59040	0.08836	0.10461	0.12149	238	2210
03	Bitterroot	12.00794	0.09493	0.11801	0.14160	154	1130
04	Clearwater	9.05874	0.12290	0.14420	0.16598	232	1588
05	Custer	10.91583	0.10714	0.13000	0.15378	159	1200
08	Flathead (part)	28.32348	0.02580	0.04571	0.06862	25	525
10	Gallatin	11.38808	0.07038	0.08652	0.10277	235	2306
11	Helena	14.52303	0.06343	0.08258	0.10303	106	1115
12	Idaho Panhandle	16.35541	0.09154	0.12374	0.15813	93	695
14	Kootenai	9.29740	0.10043	0.11837	0.13700	308	2366
15	Lewis and Clark	12.47791	0.08270	0.10337	0.12500	142	1335
16	Lolo (part)	9.72691	0.11030	0.13027	0.15189	233	1635
17	Nezperce	11.20618	0.09047	0.11038	0.13121	139	1232
NRP	NRP	4.18360	0.11041	0.11844	0.12682	1321	10225
MRP	MRP	6.07499	0.09745	0.10804	0.11903	612	5472
SRP	SRP	13.12856	0.05575	0.07077	0.08609	131	1640
R1	R1	3.35883	0.10478	0.11064	0.11716	2064	17337

Northern goshawk pfa habitat

Strata	Category	Standard Error	CI Low	Estimate	CI High	Habitat Subplots	EstimateSubplots
02	Beaverhead Deerlodge	7.78844	0.12586	0.14402	0.16252	327	2210
03	Bitterroot	11.84795	0.10165	0.12599	0.15084	163	1130
04	Clearwater	8.75544	0.13054	0.15239	0.17410	246	1588
05	Custer	11.73289	0.10047	0.12416	0.14836	154	1200
08	Flathead (part)	23.30993	0.04615	0.07238	0.10107	40	525
10	Gallatin	12.52006	0.05466	0.06869	0.08280	193	2306
11	Helena	14.37468	0.06710	0.08707	0.10820	110	1115
12	Idaho Panhandle	13.55377	0.12727	0.16258	0.20000	121	695

14	Kootenai	8.90270	0.10944	0.12812	0.14727	333	2366
15	Lewis and Clark	10.81954	0.10947	0.13258	0.15679	180	1335
16	Lolo (part)	9.05690	0.12000	0.14067	0.16217	253	1635
17	Nezperce	10.18049	0.11649	0.13961	0.16319	176	1232
NRP	NRP	4.23751	0.11150	0.11981	0.12813	1342	10225
MRP	MRP	4.94870	0.13122	0.14259	0.15433	804	5472
SRP	SRP	12.37694	0.06603	0.08236	0.09939	150	1640
R1	R1	3.12264	0.11731	0.12346	0.12990	2296	17337

Northern goshawk forage habitat

Strata	Category	Standard Error	CI Low	Estimate	CI High	Habitat Subplots	EstimateSubplots
02	Beaverhead Deerlodge	4.17469	0.37494	0.40262	0.43043	917	2210
03	Bitterroot	6.86116	0.29796	0.33540	0.37388	451	1130
04	Clearwater	4.72831	0.36381	0.39483	0.42540	641	1588
05	Custer	5.78996	0.33391	0.36916	0.40404	453	1200
08	Flathead (part)	14.03394	0.15779	0.20380	0.25263	119	525
10	Gallatin	5.64527	0.27555	0.30391	0.33204	811	2306
11	Helena	8.11064	0.23855	0.27468	0.31214	328	1115
12	Idaho Panhandle	7.54440	0.37894	0.43309	0.48652	328	695
14	Kootenai	4.81926	0.34071	0.36996	0.39911	965	2366
15	Lewis and Clark	5.94325	0.34733	0.38501	0.42274	525	1335
16	Lolo (part)	4.85386	0.37931	0.41223	0.44498	724	1635
17	Nezperce	5.62924	0.33259	0.36688	0.40079	469	1232
NRP	NRP	2.23967	0.34867	0.36181	0.37496	4045	10225
MRP	MRP	2.68908	0.37694	0.39414	0.41176	2239	5472
SRP	SRP	7.10589	0.22295	0.25198	0.28151	447	1640
R1	R1	1.67984	0.35210	0.36163	0.37194	6731	17337

Flamulated owl habitat

Strata	Category	Standard Error	CI Low	Estimate	CI High	Habitat Subplots	EstimateSubplots
02	Beaverhead Deerlodge	54.97737	0.00047	0.00271	0.00541	6	2210
03	Bitterroot	36.25393	0.00686	0.01508	0.02475	17	1130
04	Clearwater	27.18475	0.01019	0.01763	0.02590	28	1588
05	Custer	34.70369	0.00597	0.01250	0.02010	15	1200
08	Flathead (part)	133.28894	0.00000	0.00190	0.00714	2	525
10	Gallatin	36.70639	0.00288	0.00652	0.01072	16	2306
11	Helena	42.69589	0.00453	0.01256	0.02211	14	1115
12	Idaho Panhandle	53.68810	0.00279	0.01151	0.02255	8	695
14	Kootenai	28.32837	0.00647	0.01145	0.01715	29	2366
15	Lewis and Clark	45.10787	0.00237	0.00749	0.01355	10	1335
16	Lolo (part)	30.39402	0.00689	0.01284	0.01964	21	1635
17	Nezperce	26.83075	0.01241	0.02110	0.03104	30	1232

NRP	NRP	12.86197	0.00961	0.01205	0.01468	126	10225
MRP	MRP	19.60978	0.00632	0.00914	0.01223	54	5472
SRP	SRP	40.70031	0.00360	0.00915	0.01567	16	1640
R1	R1	10.37892	0.00905	0.01085	0.01273	196	17337

Pileated woodpecker nest habitat

Strata	Category	Standard Error	CI Low	Estimate	CI High	Habitat Subplots	EstimateSubplots
02	Beaverhead Deerlodge	26.22060	0.00787	0.01313	0.01908	29	2210
03	Bitterroot	22.94433	0.02549	0.03992	0.05550	51	1130
04	Clearwater	8.18178	0.15700	0.18136	0.20594	292	1588
05	Custer	10.72914	0.13621	0.16416	0.19360	200	1200
08	Flathead (part)	67.78434	0.00000	0.00761	0.01730	6	525
10	Gallatin	20.94522	0.01937	0.02913	0.03946	71	2306
11	Helena	26.26088	0.01801	0.03052	0.04425	34	1115
12	Idaho Panhandle	40.09430	0.00806	0.02014	0.03453	15	695
14	Kootenai	13.68893	0.05040	0.06448	0.07961	164	2366
15	Lewis and Clark	35.20594	0.00557	0.01198	0.01940	16	1335
16	Lolo (part)	15.28077	0.04214	0.05565	0.07021	97	1635
17	Nezperce	10.56570	0.13203	0.15909	0.18710	212	1232
NRP	NRP	5.17187	0.07522	0.08229	0.08937	875	10225
MRP	MRP	9.82970	0.03929	0.04661	0.05427	272	5472
SRP	SRP	24.86853	0.01415	0.02318	0.03337	40	1640
R1	R1	4.65973	0.06061	0.06543	0.07057	1187	17337

Pileated woodpecker winter forage habitat

Strata	Category	Standard Error	CI Low	Estimate	CI High	Habitat Subplots	EstimateSubplots
02	Beaverhead Deerlodge	21.13427	0.01335	0.01992	0.02720	44	2210
03	Bitterroot	17.24809	0.05033	0.06921	0.08935	88	1130
04	Clearwater	6.20267	0.27512	0.30604	0.33734	493	1588
05	Custer	9.23284	0.17733	0.20833	0.24006	254	1200
08	Flathead (part)	48.31941	0.00674	0.02285	0.04273	15	525
10	Gallatin	15.95813	0.03762	0.05043	0.06409	131	2306
11	Helena	20.89391	0.03634	0.05385	0.07343	61	1115
12	Idaho Panhandle	24.85413	0.03100	0.05035	0.07225	40	695
14	Kootenai	9.90767	0.10324	0.12261	0.14316	313	2366
15	Lewis and Clark	20.08145	0.02462	0.03595	0.04835	49	1335
16	Lolo (part)	12.11782	0.07187	0.08929	0.10744	157	1635
17	Nezperce	8.49130	0.20092	0.23295	0.26557	305	1232
NRP	NRP	4.14877	0.12451	0.13373	0.14289	1436	10225
MRP	MRP	7.65191	0.06631	0.07568	0.08535	438	5472
SRP	SRP	19.30525	0.03079	0.04392	0.05872	76	1640
R1	R1	3.61724	0.10077	0.10689	0.11354	1950	17337

Ecological Province (Bailey 1996) models

Flamulated owl habitat

Strata	Category	StandardError	CI Low	Estimate	CI High	Habitat Subplots	EstimateSubplots
02	Beaverhead Deerlodge	54.95396	0.00047	0.00271	0.00541	6	2210
03	Bitterroot	36.83573	0.00636	0.01419	0.02351	16	1130
04	Clearwater	30.89703	0.00763	0.01448	0.02232	23	1588
05	Custer	37.35063	0.00479	0.01083	0.01791	13	1200
08	Flathead (part)	133.13920	0.00000	0.00190	0.00714	2	525
10	Gallatin	53.34612	0.00085	0.00347	0.00683	8	2306
11	Helena	42.71001	0.00455	0.01256	0.02212	14	1115
12	Idaho Panhandle	53.50864	0.00281	0.01151	0.02255	8	695
14	Kootenai	36.12173	0.00307	0.00678	0.01114	16	2366
15	Lewis and Clark	45.17114	0.00237	0.00749	0.01358	10	1335
16	Lolo (part)	34.19551	0.00477	0.00978	0.01572	16	1635
17	Nezperce	26.85807	0.01238	0.02110	0.03104	30	1232
NRP	NRP	14.62619	0.00691	0.00901	0.01122	92	10225
MRP	MRP	19.62311	0.00630	0.00914	0.01222	54	5472
SRP	SRP	40.75586	0.00356	0.00915	0.01573	16	1640
Region1	Region1	11.54997	0.00736	0.00906	0.01079	162	17337

Northern goshawk habitat

Strata	Category	StandardError	CI Low	Estimate	CI High	Habitat Subplots	EstimateSubplots
02	Beaverhead Deerlodge	7.79920	0.12577	0.14402	0.16255	327	2210
03	Bitterroot	22.47736	0.02297	0.03549	0.04930	44	1130
04	Clearwater	14.24359	0.04601	0.05982	0.07407	97	1588
05	Custer	21.27017	0.02539	0.03833	0.05215	48	1200
08	Flathead (part)	23.37725	0.04600	0.07238	0.10166	40	525
10	Gallatin	22.27006	0.01183	0.01826	0.02511	54	2306
11	Helena	14.40025	0.06700	0.08707	0.10813	110	1115
12	Idaho Panhandle	13.56275	0.12740	0.16258	0.20000	121	695
14	Kootenai	15.81954	0.02997	0.03988	0.05086	98	2366
15	Lewis and Clark	10.83005	0.10944	0.13258	0.15677	180	1335
16	Lolo (part)	18.11776	0.02356	0.03302	0.04334	60	1635
17	Nezperce	10.20005	0.11645	0.13961	0.16329	176	1232
NRP	NRP	7.46606	0.03200	0.03634	0.04082	401	10225
MRP	MRP	4.94154	0.13119	0.14259	0.15430	804	5472
SRP	SRP	12.37856	0.06591	0.08236	0.09947	150	1640
Region1	Region1	4.12126	0.06933	0.07426	0.07951	1355	17337

Northern goshawk habitat

Strata	Category	StandardError	CI Low	Estimate	CI High	Habitat Subplots	EstimateSubplots
02	Beaverhead Deerlodge	23.72637	0.01059	0.01675	0.02360	38	2210
03	Bitterroot	44.67541	0.00292	0.00887	0.01603	11	1130
04	Clearwater	27.20612	0.00977	0.01700	0.02493	29	1588
05	Custer	29.70238	0.00958	0.01750	0.02664	22	1200
08	Flathead (part)	137.75739	0.00000	0.00190	0.00720	1	525
10	Gallatin	67.97908	0.00000	0.00260	0.00589	8	2306
11	Helena	41.37176	0.00345	0.00897	0.01555	13	1115
12	Idaho Panhandle	37.78146	0.00916	0.02158	0.03612	19	695
14	Kootenai	26.22529	0.00810	0.01357	0.01971	33	2366
15	Lewis and Clark	34.12974	0.00534	0.01123	0.01795	15	1335
16	Lolo (part)	32.07775	0.00567	0.01100	0.01721	21	1635
17	Nezperce	30.97195	0.00803	0.01542	0.02380	19	1232
NRP	NRP	13.55523	0.00867	0.01116	0.01358	124	10225
MRP	MRP	14.98904	0.01200	0.01572	0.01972	91	5472
SRP	SRP	40.25730	0.00256	0.00671	0.01148	14	1640
Region1	Region1	9.81022	0.01030	0.01218	0.01424	229	17337

Idaho Panhandle National Forests

Flammulated owl habitat

Strata	Category	StandardError	CI Low	Estimate	CI High	Habitat Subplots	EstimateSubplots
17010104	SD_4_CODE_HUC	0	0	0.00000	0	0	188
17010105	SD_4_CODE_HUC	0	0	0.00000	0	0	76
17010213	SD_4_CODE_HUC	134.21281	0	0.01562	0.05769	1	64
17010214	SD_4_CODE_HUC	86.21068	0	0.02419	0.0625	3	124
17010215	SD_4_CODE_HUC	92.77311	0	0.00943	0.02631	2	212
17010216	SD_4_CODE_HUC	0	0	0.00000	0	0	4
17010301	SD_4_CODE_HUC	94.1833	0	0.00574	0.01612	2	348
17010302	SD_4_CODE_HUC	138.12144	0	0.02777	0.10416	1	36
17010303	SD_4_CODE_HUC	134.95366	0	0.01785	0.06666	1	56
17010304	SD_4_CODE_HUC	93.51797	0	0.00549	0.01543	2	364
17010305	SD_4_CODE_HUC	0	0	0.00000	0	0	20
17060308	SD_4_CODE_HUC	133.80352	0	0.01041	0.03846	1	96
M333Aa	SD_ECO_SUBSECTION	71.86184	0	0.03448	0.08035	4	116
M333Ab	SD_ECO_SUBSECTION	0	0	0.00000	0	0	296
M333Ba	SD_ECO_SUBSECTION	0	0	0.00000	0	0	180
M333Be	SD_ECO_SUBSECTION	0	0	0.00000	0	0	36
M333Da	SD_ECO_SUBSECTION	53.04812	0.00227	0.01219	0.0238	6	492
M333Db	SD_ECO_SUBSECTION	76.30136	0	0.00765	0.01861	3	392
M333Dd	SD_ECO_SUBSECTION	0	0	0.00000	0	0	76
04	FOREST	37.31159	0.00374	0.00818	0.01364	13	1588

Northern goshawk forage habitat

Strata	Category	StandardError	CI Low	Estimate	CI High	Habitat Subplots	EstimateSubplots
17010104	SD_4_CODE_HUC	19.57795	0.1576	0.22872	0.30405	46	188
17010105	SD_4_CODE_HUC	29.66012	0.14062	0.26315	0.39583	23	76
17010213	SD_4_CODE_HUC	32.26842	0.13235	0.26562	0.41176	17	64
17010214	SD_4_CODE_HUC	22.65691	0.18	0.28225	0.39102	37	124
17010215	SD_4_CODE_HUC	15.29866	0.23728	0.31603	0.39622	68	212
17010216	SD_4_CODE_HUC	0	0	0.00000	0	0	4
17010301	SD_4_CODE_HUC	10.16197	0.33536	0.40229	0.46978	141	348
17010302	SD_4_CODE_HUC	35.14699	0.15	0.33333	0.53125	12	36
17010303	SD_4_CODE_HUC	26.85105	0.1923	0.33928	0.5	19	56
17010304	SD_4_CODE_HUC	13.48893	0.21306	0.27197	0.33333	99	364
17010305	SD_4_CODE_HUC	32.67846	0.25	0.55000	0.83334	11	20
17060308	SD_4_CODE_HUC	28.14734	0.1375	0.25000	0.36956	24	96
M333Aa	SD_ECO_SUBSECTION	23.06057	0.16964	0.26724	0.37068	34	116
M333Ab	SD_ECO_SUBSECTION	14.28217	0.21036	0.27364	0.33974	84	296
M333Ba	SD_ECO_SUBSECTION	20.91339	0.14444	0.21666	0.29347	42	180
M333Be	SD_ECO_SUBSECTION	44.7174	0.06818	0.22222	0.39285	8	36
M333Da	SD_ECO_SUBSECTION	8.28537	0.3545	0.41056	0.46638	203	492
M333Db	SD_ECO_SUBSECTION	13.15345	0.211	0.26785	0.32675	105	392
M333Dd	SD_ECO_SUBSECTION	28.05951	0.15384	0.27631	0.40625	21	76
04	FOREST	5.79615	0.2777	0.30667	0.33607	497	1588

IPNFs northern goshawk nest habitat

Strata	Category	StandardError	CI Low	Estimate	CI High	Habitat Subplots	EstimateSubplots
17010104	SD_4_CODE_HUC	0	0	0.00000	0	1	188
17010105	SD_4_CODE_HUC	134.56309	0	0.01315	0.04807	1	76
17010213	SD_4_CODE_HUC	0	0	0.00000	0	0	64
17010214	SD_4_CODE_HUC	132.73292	0	0.00806	0.02941	1	124
17010215	SD_4_CODE_HUC	85.68013	0	0.01415	0.03703	4	212
17010216	SD_4_CODE_HUC	0	0	0.00000	0	0	4
17010301	SD_4_CODE_HUC	58.55176	0.00274	0.01436	0.02989	5	348
17010302	SD_4_CODE_HUC	137.90376	0	0.02777	0.10416	1	36
17010303	SD_4_CODE_HUC	92.45186	0	0.03571	0.1	2	56
17010304	SD_4_CODE_HUC	45.94804	0.00949	0.03021	0.05494	11	364
17010305	SD_4_CODE_HUC	140.57361	0	0.05000	0.1875	1	20
17060308	SD_4_CODE_HUC	93.82111	0	0.02083	0.05833	2	96
M333Aa	SD_ECO_SUBSECTION	0	0	0.00000	0	1	116
M333Ab	SD_ECO_SUBSECTION	85.78876	0	0.01013	0.02631	4	296
M333Ba	SD_ECO_SUBSECTION	93.61016	0	0.01111	0.03125	2	180
M333Be	SD_ECO_SUBSECTION	0	0	0.00000	0	0	36
M333Da	SD_ECO_SUBSECTION	46.52557	0.00505	0.01626	0.02976	8	492
M333Db	SD_ECO_SUBSECTION	44.68355	0.00952	0.02806	0.0505	11	392
M333Dd	SD_ECO_SUBSECTION	85.58203	0	0.03947	0.10294	3	76
04	FOREST	27.44578	0.0099	0.01700	0.02506	29	1588

IPNFs northern goshawk pfa habitat

Strata	Category	StandardError	CI Low	Estimate	CI High	Habitat Subplots	EstimateSubplots
17010104	SD_4_CODE_HUC	57.36364	0.00595	0.03723	0.07608	8	188
17010105	SD_4_CODE_HUC	93.43112	0	0.02631	0.07352	2	76

17010213	SD_4_CODE_HUC	134.22702	0	0.01562	0.05769	1	64
17010214	SD_4_CODE_HUC	57.10298	0.00781	0.04032	0.08108	5	124
17010215	SD_4_CODE_HUC	35.72978	0.03431	0.07547	0.12264	17	212
17010216	SD_4_CODE_HUC	0	0	0.00000	0	0	4
17010301	SD_4_CODE_HUC	23.03808	0.06024	0.09482	0.13202	33	348
17010302	SD_4_CODE_HUC	0	0	0.00000	0	0	36
17010303	SD_4_CODE_HUC	53.4508	0.02272	0.10714	0.20833	6	56
17010304	SD_4_CODE_HUC	33.71187	0.02644	0.05494	0.0875	20	364
17010305	SD_4_CODE_HUC	141.18148	0	0.05000	0.1875	1	20
17060308	SD_4_CODE_HUC	64.63919	0	0.04166	0.09	4	96
M333Aa	SD_ECO_SUBSECTION	92.90263	0	0.01724	0.04807	3	116
M333Ab	SD_ECO_SUBSECTION	33.18157	0.03308	0.06756	0.10666	21	296
M333Ba	SD_ECO_SUBSECTION	52.76843	0.00675	0.03333	0.06521	6	180
M333Be	SD_ECO_SUBSECTION	0	0	0.00000	0	0	36
M333Da	SD_ECO_SUBSECTION	20.08935	0.05978	0.08739	0.11752	43	492
M333Db	SD_ECO_SUBSECTION	33.58829	0.02477	0.05102	0.08132	20	392
M333Dd	SD_ECO_SUBSECTION	71.29784	0	0.05263	0.125	4	76
04	FOREST	14.37292	0.04601	0.05982	0.07442	97	1588

Black-backed woodpecker foraging habitat

Strata	Category	StandardError	CI Low	Estimate	CI High	Habitat Subplots	EstimateSubplots
17010104	SD_4_CODE_HUC	14.50788	0.3173	0.41489	0.515	83	188
17010105	SD_4_CODE_HUC	20.24239	0.30952	0.46052	0.61539	36	76
17010213	SD_4_CODE_HUC	35.2137	0.1	0.21875	0.35	14	64
17010214	SD_4_CODE_HUC	22.17752	0.1875	0.29032	0.39843	36	124
17010215	SD_4_CODE_HUC	17.07364	0.205	0.28301	0.36363	62	212
17010216	SD_4_CODE_HUC	0	0	0.00000	0	0	4
17010301	SD_4_CODE_HUC	16.52089	0.17091	0.23275	0.29687	81	348
17010302	SD_4_CODE_HUC	34.38562	0.16666	0.36111	0.56819	13	36
17010303	SD_4_CODE_HUC	83.93851	0	0.07142	0.18181	4	56
17010304	SD_4_CODE_HUC	12.91042	0.25342	0.32142	0.39077	117	364
17010305	SD_4_CODE_HUC	83.64591	0	0.15000	0.375	3	20
17060308	SD_4_CODE_HUC	58.9272	0.01041	0.07291	0.15	7	96
M333Aa	SD_ECO_SUBSECTION	27.69955	0.12068	0.21551	0.31818	27	116
M333Ab	SD_ECO_SUBSECTION	14.25105	0.22887	0.29729	0.36824	93	296
M333Ba	SD_ECO_SUBSECTION	12.57779	0.38333	0.48333	0.58334	88	180
M333Be	SD_ECO_SUBSECTION	58.41176	0.02083	0.13888	0.28571	5	36
M333Da	SD_ECO_SUBSECTION	13.50844	0.18452	0.23577	0.28899	116	492
M333Db	SD_ECO_SUBSECTION	14.41831	0.1975	0.25765	0.3193	101	392
M333Dd	SD_ECO_SUBSECTION	28.39431	0.1875	0.34210	0.5	26	76
04	FOREST	6.59963	0.25187	0.28211	0.31312	456	1588

Black-backed woodpecker nest habitat

Strata	Category	StandardError	CI Low	Estimate	CI High	Habitat Subplots	EstimateSubplots
17010104	SD_4_CODE_HUC	8.3599	0.56373	0.65426	0.74343	128	188
17010105	SD_4_CODE_HUC	13.27206	0.53001	0.68422	0.82895	53	76
17010213	SD_4_CODE_HUC	18.79294	0.38461	0.56250	0.73334	36	64
17010214	SD_4_CODE_HUC	8.7624	0.61112	0.71775	0.81819	90	124
17010215	SD_4_CODE_HUC	6.6811	0.64394	0.72642	0.80455	163	212
17010216	SD_4_CODE_HUC	0	0	1.00000	0	4	4
17010301	SD_4_CODE_HUC	6.89305	0.55748	0.62932	0.7	221	348
17010302	SD_4_CODE_HUC	23.30669	0.32142	0.52778	0.725	19	36

17010303	SD_4_CODE_HUC	14.86154	0.5	0.67858	0.83929	38	56
17010304	SD_4_CODE_HUC	6.56531	0.52885	0.59341	0.65722	216	364
17010305	SD_4_CODE_HUC	34.24681	0.25	0.60000	0.95834	12	20
17060308	SD_4_CODE_HUC	14.75694	0.37903	0.50000	0.61957	48	96
M333Aa	SD_ECO_SUBSECTION	11.7194	0.48529	0.60345	0.71775	76	116
M333Ab	SD_ECO_SUBSECTION	6.03536	0.63514	0.70609	0.77574	218	296
M333Ba	SD_ECO_SUBSECTION	7.86097	0.60715	0.70000	0.78774	127	180
M333Be	SD_ECO_SUBSECTION	24.29618	0.33333	0.55556	0.77778	20	36
M333Da	SD_ECO_SUBSECTION	5.58931	0.58209	0.64228	0.70042	318	492
M333Db	SD_ECO_SUBSECTION	6.74965	0.49184	0.55358	0.61449	217	392
M333Dd	SD_ECO_SUBSECTION	12.02902	0.54546	0.68422	0.81667	52	76
04	FOREST	3.02469	0.60444	0.63603	0.66771	1028	1588

IPNFs pileated woodpecker foraging habitat

Strata	Category	StandardError	CI Low	Estimate	CI High	Habitat Subplots	EstimateSubplots
17010104	SD_4_CODE_HUC	27.41602	0.08173	0.14361	0.21111	28	188
17010105	SD_4_CODE_HUC	28.23017	0.15277	0.27631	0.40789	21	76
17010213	SD_4_CODE_HUC	38.20567	0.11111	0.28125	0.46428	18	64
17010214	SD_4_CODE_HUC	17.95834	0.28571	0.40322	0.5242	51	124
17010215	SD_4_CODE_HUC	12.87925	0.33823	0.42924	0.52084	94	212
17010216	SD_4_CODE_HUC	0	0	0.00000	0	0	4
17010301	SD_4_CODE_HUC	10.56972	0.31593	0.38218	0.44871	135	348
17010302	SD_4_CODE_HUC	58.22139	0	0.22222	0.45	8	36
17010303	SD_4_CODE_HUC	22.9204	0.3	0.48214	0.66667	27	56
17010304	SD_4_CODE_HUC	15.51765	0.16898	0.22527	0.28437	82	364
17010305	SD_4_CODE_HUC	57.98741	0	0.35000	0.7	7	20
17060308	SD_4_CODE_HUC	29.64855	0.125	0.22916	0.34523	22	96
M333Aa	SD_ECO_SUBSECTION	17.367	0.30882	0.43103	0.55556	54	116
M333Ab	SD_ECO_SUBSECTION	15.35835	0.21103	0.28040	0.35245	84	296
M333Ba	SD_ECO_SUBSECTION	22.22005	0.14285	0.22222	0.30555	40	180
M333Be	SD_ECO_SUBSECTION	62.96214	0	0.16666	0.35714	6	36
M333Da	SD_ECO_SUBSECTION	8.78993	0.34297	0.40040	0.45867	199	492
M333Db	SD_ECO_SUBSECTION	15.01631	0.16463	0.21683	0.2715	85	392
M333Dd	SD_ECO_SUBSECTION	28.6317	0.17857	0.32894	0.48684	25	76
04	FOREST	6.14325	0.27549	0.30604	0.33712	493	1588

IPNFs pileated woodpecker nesting habitat

Strata	Category	StandardError	CI Low	Estimate	CI High	Habitat Subplots	EstimateSubplots
17010104	SD_4_CODE_HUC	38.01261	0.02906	0.06914	0.11538	13	188
17010105	SD_4_CODE_HUC	49.21069	0.025	0.09210	0.17187	7	76
17010213	SD_4_CODE_HUC	40.69303	0.08333	0.21875	0.375	14	64
17010214	SD_4_CODE_HUC	23.97502	0.16	0.25806	0.3629	32	124
17010215	SD_4_CODE_HUC	18.91878	0.18032	0.25943	0.3421	57	212
17010216	SD_4_CODE_HUC	0	0	0.00000	0	0	4
17010301	SD_4_CODE_HUC	15.4186	0.15789	0.20977	0.26453	75	348
17010302	SD_4_CODE_HUC	58.32688	0	0.22222	0.45	8	36
17010303	SD_4_CODE_HUC	29.93356	0.17857	0.33928	0.5	19	56
17010304	SD_4_CODE_HUC	20.87048	0.08256	0.12362	0.16755	45	364
17010305	SD_4_CODE_HUC	59.04401	0	0.25000	0.5	5	20
17060308	SD_4_CODE_HUC	32.90831	0.08653	0.17708	0.27678	17	96
M333Aa	SD_ECO_SUBSECTION	20.31054	0.2258	0.33620	0.45	41	116
M333Ab	SD_ECO_SUBSECTION	22.02289	0.10333	0.15878	0.21785	47	296

M333Ba	SD_ECO_SUBSECTION	38.07664	0.03571	0.08333	0.13953	15	180
M333Be	SD_ECO_SUBSECTION	64.29325	0	0.13888	0.3	5	36
M333Da	SD_ECO_SUBSECTION	12.37634	0.18584	0.23170	0.27952	116	492
M333Db	SD_ECO_SUBSECTION	18.61045	0.10238	0.14540	0.19117	57	392
M333Dd	SD_ECO_SUBSECTION	43.74196	0.05	0.14473	0.25	11	76
04	FOREST	8.23547	0.15712	0.18136	0.20643	292	1588

Appendix 4

Methods to Estimate Forested Habitat

William Tanke, Northern Region, Missoula, MT

West-side Forests

Data Sets

Data sets used in this analysis were obtained from the R1 Geospatial Library and included:
- Ownership (Forest Service) for Region 1 - 1:126,720
- Ecological Unit Subsections for Region 1 - 1:500,000
- Vegetation (vmap - lifeform) for western Region 1

Processing steps

All processing was done in ArcMap (v8.3)

1. Converted Ownership and Subsections to 15 meter grid to match lifeform data (resulting datasets: fsown_g, subsec_g)
2. In Raster Calculator performed a combine operation on Ownership, Subsection and Lifeform Grid (resulting dataset: for_subsec_lf)
3. Joined Ownership, Subsection and Lifeform attributes to the for_subset_lf Grid
4. Exported the for_subsec_lf attribute table and converted to an Excel spreadsheet
5. In Excel:
    - Removed unnecessary columns
    - Computed acres based on 15 x 15 meter grid cells
    - Summarized results using a pivot table

Accuracy Issues

The datasets used to generate these results have some limitations and therefore the accuracy of this analysis should be considered as gross estimates only. The biggest concern is with the use of the ecological subsections which are 1:500,000 scale data (approx. 1/8 inch on a map of this scale equals 1 mile on the ground). I'd recommend displaying these results to the nearest 1,000 or 10,000 acres rather then to the nearest acre.

East-side Forests

This analysis is similar to that done for the 7 west-side forests (Idaho Panhandle, Nezperce, Clearwater, Kootenai, Flathead, Bitterroot, Lolo) using R1Vmap data to determined forested lands. A dataset which is a combination of SILC2 and SILC3 was used to determine forested lands for 5 east side Forests (Beaverhead-Deerlodge, Custer, Gallatin, Helena, Lewis & Clark).

Information for the Dakota Prairie was not included because we did not have a dataset for determining forested lands.

Small portions of the Lolo and the Flathead NF were not included in the previous west-side analysis because the R1Vmap data did not cover these areas. The excluded portions for these to Forests were included in this analysis

Data Sets

Data sets used in this analysis were obtained from the R1 Geospatial Library and included:

- Ownership (Forest Service) for Region 1 - 1:126,720
- Ecological Unit Subsections for Region 1 - 1:500,000
- Hydrologic Unit Boundaries (5th code) for Region 1
- Vegetation (mtsilc3) for eastern Region 1

Processing steps

Processing was done in ArcMap (v9.0) and Workstation ArcInfo (v9.0)

6. Projected mtsilc3 to standard projection used in RO (resulting dataset mtsilc3_prj)
7. Selected Covertypes > 4000 and < 4400 to produce a dataset of Forested lands (mtsilc3_tree)
8. Converted Ownership, Subsections and Fifth Code HUC's to 30 meter grid to match mtsilc3_prj (resulting datasets: fsown_g, subsect_g, huc5_g)
9. Using fsown_g produced an ownership grid which only included the 5 eastside forests plus the portions of the Lolo and Flathead which were not included in the previous analysis for the Westside (fsown_es)
10. Performed 3 combine operations as follows:
    - fsown_g, mtsilc3_tree – to obtain forested acres by unit (resultant grid: fsown_tree
    - fsown_g, mtsilc3_tree, huc5_g – to obtain forested acres by unit by fifth code HUC (resultant grid: fsown_huc5)
    - fsown_g, mtsilc3_tree, subsect_g – to obtain forested acres by unit by subsection (resultant grid: fsown_subsect)
11. Joined appropriate attributes to each of the three grids created in step 4 as follows:
    - For fsown_tree joined attributes from fsown_g
    - For fsown_huc5 joined attributes from fsown_g and huc5_g
    - For fsown_subsect joined attributes from fsown_g and subsect_g
12. Exported the attribute tables for the three resultant grids from step 5 and converted to an Excel spreadsheet
13. In Excel:
    - Removed unnecessary columns
    - Computed acres based on 30 x 30 meter grid cells
    - Summarized results using a pivot table

Accuracy Issues

The datasets used to generate these results have some limitations and therefore the accuracy of this analysis should be considered as gross estimates only. The biggest concern is with the use of the ecological subsections which are 1:500,000 scale data (approx. 1/8 inch on a map of this scale equals 1 mile on the ground). I'd recommend displaying these results to the nearest 1,000 or 10,000 acres rather then to the nearest acre.

Appendix 5

Common and Scientific Names.

Black cottonwood *Populus tricocarpa*
Douglas-fir *Pseudotsuga menziesii*
Grand fir *Abies grandis*
Jeffery pine *Pinus jeffreyi*
Lodgepole pine *Pinus contorta*
Paper birch *Betula papyrifera*
Ponderosa pine *Pinus ponderosa*
Quaking aspen *Populau tremuloides*
Sagebrush woody *Artemisa* spp.
Western hemlock *Tsuga heterophylla*
Western larch *Larix occidentalis*
Western red cedar *Thuja plicata*
White pine *Pinus albicaulis*
Whitebark pine *Pinus monticola*

Carpenter ants *Camponotus* spp.
Mountain pine beetle *Dendroctous ponderosae*
Western pine beetle *Dendroctous brevicomis*
Whitespotted sawyer beetle *Monochamus scutellatus*

Barred owl *Strix varia*
Black-backed woodpecker *Picoides arcticus*
Cooper's hawk *Accipiter cooperii*
Flammulated owl *Otus flammeolus*
Great horned owl *Bubo virginianus*
Imperial woodpecker *Campephilus principalis*
Ivory billied woodpecker *Campephilusimperialis*
Northern goshawk *Accipiter gentilis*
Pileated woodpecker *Dryocopus pileatus*
Red-tailed hawk *Buteo jamaicensis*
Ruffed grouse *Bonasa umbellus*
Sage grouse *Centrocercus urophasianus*
Spotted owl *Strix occidentalis*
Three-toed woodpecker *Picoides tridactylus*

American marten *Martes americana*
Gray fox *Urocyon cinereoargenteus*
Grizzly bear *Ursus arctos*
Long-tailed weasel *Mustela frenata*
Snowshoe hare *Lepus americanus*

Appendix 6

Vegetation Council Report

Vegetation Council Algorithms for Stand Classification

The following documents the algorithms used by the R1 Summary Database and the Forest Vegetation Simulator (FVS) Classifier post-processor for assigning species dominance type, stand size, and vertical structure.

Dominance Type:

<u>Dominance Type (Elemental)</u>

1. For plots/stands with $\geq$ 20 square feet of basal area, dominance is based on basal area.
2. If a plot/stand has < 20 square feet of basal area but $\geq$ 100 trees per acre then dominance is based on trees per acre.
3. If neither basal area nor trees per acre criteria is met, a dominance call is not made and will be labeled as 'none' in the database.
4. The proportion of the dominance attribute, either basal area or trees per acre, is then calculated for each species occurring on the plots/stands. See Appendix A for a key to valid species and species groups.

- **Single species** – Species comprises $\geq$ 60% of the dominance attribute.
- **Two species** - Two species comprise $\geq$80% of the dominance attribute with each individual species contributing >20% of the total.
    - Assign label in order of abundance. If proportion of dominance attribute is equal between 2 species, assign label based on the species with the largest BA(TPA)-weighted DBH being first in the order. If the BA(TPA)-weighted DBH is equal then assign label based on the species with largest average tree height.
- **Three species** – Three species comprise $\geq$80% of the dominance attribute with each individual contributing > 20% of the total.
    - Assign label in order of abundance. If proportion of dominance attribute is equal between the 2 or all 3 species, assign label based on the species with the largest BA(TPA)-weighted DBH being first in the order. If the BA(TPA)-weighted DBH is equal then assign label based on the species with largest average tree height
- **Mix** – No Single, Two, or Three species call can be made. Type of mix, either intolerant or tolerant, is determined by what species combination has plurality of dominance attribute.
    - If proportion of dominance attribute of IMXS > TGCH + TASH, then assign to IMXS.
    - If IMXS = Tolerant Species (TGCH + TASH) then label based on the "mix" with the largest BA(TPA)-weighted DBH. If the BA(TPA)-weighted DBH of the mixes are equal then assign label based on the largest BA(TPA)-weighted tree height for the mix.

- If the result is not IMXS and TGCH > TASH, then label as TGCH
- If the result is not IMXS and TASH > TGCH, then label as TASH
- If TGCH = TASH then assign label based on the "mix" with the largest BA(TPA)-weighted DBH. If the BA(TPA)-weighted DBH of TASH = TGCH then assign label to the mix with largest BA(TPA)-weighted tree height.

Collapsed Dominance Type Same logic as Elemental Dominance Type however any three species dominance type is re-classified according to Mix algorithm described above. In FVS Classifier program, if 3 species includes "2Tree" then label as UNCL.

Dominance Group: Similar to Collapsed Dominance Type except 2-species types are grouped based on the most abundant species.

If collapsed dominance is 1 species or a mix (TASH, TCGH, IMXS) or UNCL then dominance group = collapsed dominance.

If collapsed dominance is 2 species then dominance group = the first species plus "-1MIX" (For example ABGR-PSME, ABGR-PICO and ABGR-THPL are grouped into ABGR-1MIX)

Dominance Set:

- similar to dominance type – elemental, except for mixed types

1. For plots/stands with ≥ 20 square feet of basal area, dominance is based on basal area.
2. If a plot/stand has < 20 square feet of basal area but ≥ 100 trees per acre then dominance is based on trees per acre.
3. If neither basal area nor trees per acre criteria is met, a dominance call is not made and will be labeled as 'none' in the database.
4. The proportion of the dominance attribute, either basal area or trees per acre, is then calculated for each species occurring on the plots/stands. See Appendix A for a key to valid species and species groups.

- **Single species** – Species comprises ≥ 60% of the dominance attribute.
- **Two species** - Two species comprise ≥80% of the dominance attribute with each individual species contributing >20% of the total.
  - Assign label in order of abundance. If proportion of dominance attribute is equal between 2 species, assign label based on the species with the largest BA(TPA)-weighted DBH being first in the order. If the BA(TPA)-weighted DBH is equal then assign label based on the species with largest average tree height.
- **Three species** – Three species comprise ≥80% of the dominance attribute with each individual contributing > 20% of the total.
  - Assign label in order of abundance. If proportion of dominance attribute is equal between the 2 or all 3 species, assign label based on the species with the largest BA(TPA)-weighted DBH being first in the order. If the BA(TPA)-weighted DBH is equal then assign label based on the species with largest average tree height

- **Mix** – No Single, Two, or Three species call can be made. Type of mix, either intolerant or tolerant, is determined by what species combination has plurality of dominance attribute.
    - If proportion of dominance attribute of **IMIX** > **TMIX,** then assign to **IMIX.**
    - If **IMIX = TMIX** then label based on the "mix" with the largest BA(TPA)-weighted DBH. If the BA(TPA)-weighted DBH of the mixes are equal then assign label based on the largest BA(TPA)-weighted tree height for the mix.

Dominance Cluster:

- **Single species** – Single species comprises ≥ 60% of the dominance attribute.
- **Mixed species** -- determined by what mixed-species type**, IMIX or TMIX**, has plurality of dominance attribute. See Appendix A for definition.

1. If **IMIX = TMIX** then label based on the "mix" with the largest BA(TPA)-weighted DBH. If the BA(TPA)-weighted DBH of the mixes are equal then assign label based on the largest BA(TPA)-weighted tree height for the mix.
2. Regardless of the mixed-species type, select the largest individual species dominance attribute percentage, if ≥ 40% of the total dominance attribute, label the mixed-species type with that individual species. Labels such as PSME-TMIX or ABLA-IMIX are "permitted". If 2 species are tied for the largest percentage, assign label based on the species with the largest BA(TPA)-weighted DBH. If the BA(TPA)-weighted DBH of the 2 species are equal then assign label based on the largest BA(TPA)-weighted tree height.

   Example:

Species	% of total canopy cover
PSME	45
THPL	20
ABGR	10
ABLA	15
PIEN	10

   Label the above example as PSME-TMIX
3. If the largest individual species dominance attribute percentage is <40%, retain the label of the dominant mixed species type in step 1.

Size Class Categories:

Size_Class_NTG: **N**ational **T**echnical **G**uide for Existing Veg. Mapping and Classification http://www.fs.fed.us/emc/rig/includes/veg/section3_2004.pdf

Plots/stands must have at least 20 square feet of basal area or 100 trees per acre in order to have size computed. Otherwise, the size label is 'none'. Size class category is based on basal area weighted diameter of the plot/stand. Basal area weighted diameter (BAwtDBH) is the sum of the diameter of tree, times the number of trees the tree represents times basal area of tree. This sum is divided by total basal area. Weighted diameter is calculated then classification is made as follows according to weighted diameter:

NTG Size Class Label	RULESET* for basal area weighted diameter
• Seedling	If 100 or more trees per acre are present but basal area weighted diameter is 0.0 or null.
• 0.1 – 4.9”	0.0 ≤ BAwtDBH < 5.0*
• 5.0 – 9.9”	5.0 ≤ BAwtDBH <10.0
• 10.0 – 14.9”	10.0 ≤ BAwtDBH <15.0
• 15.0 – 19.9”	15.0 ≤ BAwtDBH <20.0
• 20.0 – 24.9”	20.0 ≤ BAwtDBH <25.0
• 25.0+”	BAwtDBH ≥ 25.0

Size_Class_Trad: **Trad**itional Region One TSMRS sizeclass. http://fsweb.r1.fs.fed.us/directives/html/fsh2000.html
Plots/stands must have at least 20 square feet of basal area or 100 trees per acre in order to have size computed. Otherwise, the size label is ‘none’. Size class category is based on basal area weighted diameter of the plot/stand. Basal area weighted diameter (BAwtDBH) is the sum of the diameter of tree, times the number of trees the tree represents times basal area of tree. This sum is divided by total basal area. Weighted diameter is calculated then classification is made as follows according to weighted diameter:

Trad Size Class Label	RULESET* for basal area weighted diameter
• Seedling	If 100 or more trees per acre are present but basal area weighted diameter is 0.0 or null.
• 0.1 – 0.9” DBH	0.0 ≤ BAwtDBH <1.0
• 1.0 – 4.9”	0.1 ≤ BAwtDBH <5.0
• 5.0 – 8.9”	5.0 ≤ BAwtDBH <9.0
• 9.0 – 13.9”	9.0 ≤ BAwtDBH <14.0
• 14.0 – 20.9”	14.0 ≤ BAwtDBH <21.0
• 21.0” +	BAwtDBH ≥21

* definition is “expanded” to assure classification of BA-Weighted DBH between class boundaries, such as between 4.9000001 and 4.999999

Vertical Structure:

There are 5 possible vertical structure classes: 1 = single story, 2 = two-story, 3 = three-story, C = continuous, none = insufficient ba/tpa found on the plot/stand.

Vertical Structure Categories:

The proportion of total basal area for the following diameter classes: 0-4.9”, 5.0-9.9”, 10.0-14.9”, 15.0-19.9”, 20.0-24.9”, 25.0”+, for a plots/stand that has at least 20 square feet of basal area is calculated, multiplied by 100 and rounded to the nearest percent. If a plot has less than 20 square feet of basal area but at least 100 trees per acre, a single story class is assigned. Initially, every plot/stand is classified as having 1 layer of vertical structure.

The following algorithm is done in the order stated:

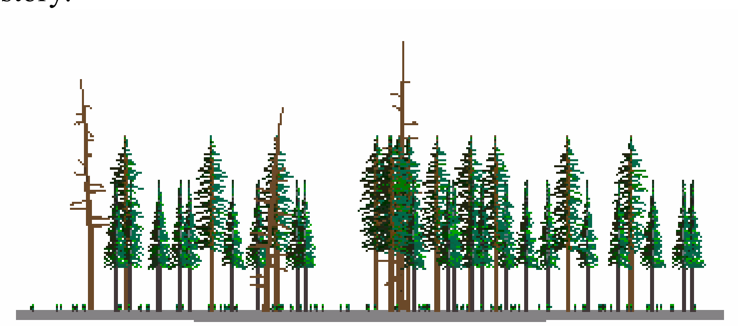
1. For any 3 consecutive diameter classes ordered largest to smallest, if the first (largest) and third (smallest) diameter class each have at least 2% of the total basal area, and if the percent of basal area in the first and third diameter class are at least 1.8 times larger than the proportion of basal area in the middle diameter class then, add a layer.
2. For any 4 consecutive diameter classes ordered from largest to smallest, if the middle 2 diameter class proportions are within 10% of each other, and the smallest and largest diameter classes each have at least 2% of the basal area, and each have at least 90% of the sum of the middle 2 diameter classes proportions then, add a layer.
3. If layer still equals 1 and at least 5 consecutive classes have ≥ 2% basal area, then vertical structure is continuous.
4. If layer equals 1 and the 3 smallest (0-4.9, 5.0-9.9, 10.0-14.9) diameter classes have ≥ 2% basal area, then vertical structure is continuous.

Examples of Vertical Structure Algorithm:

Example 1:

Percent BA by Diameter Class						**Vertical Structure Class**
25+	20-25	15-20	10-15	5-10	0-5	
0	0	0	50	50	0	1

This example does not qualify for any of the vertical structure class rules therefore it is single story.



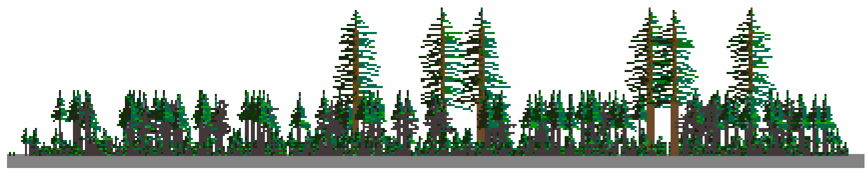
SVS image of Example 1 data.

Example 2:

Percent BA by Diameter Class						**Vertical Structure Class**
25+	20-25	15-20	10-15	5-10	0-5	
0	25	0	0	50	25	2

See rule #2. This example classifies to 2 vertical layers when looking at the % of basal area in diameter classes 20-25 through 5-10. The middle 2 diameter class both have a percent of ba within 10% of each other, they are both 0. 90% of the sum of these 2 classes is 0. The largest

(25) and smallest (50) diameter classes both have a percent basal area greater than 0. Therefore this stand is 2 layers.

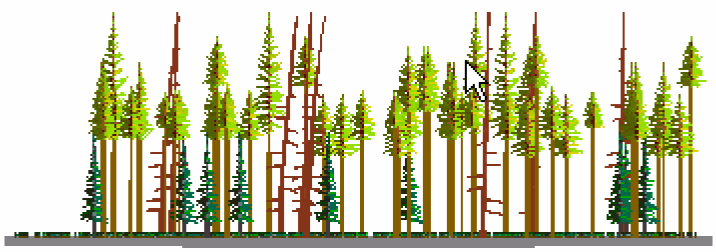


SVS image of Example 2 data.

Example 3:

Percent BA by Diameter Class						**Vertical Structure Class**
25+	20-25	15-20	10-15	5-10	0-5	
0	0	0	47	51	2	C

This example does not meet criteria 1-3 however the smallest 3 diameter classes have ≥ 2% basal area, so vertical structure is continuous.



SVS image of Example 3 data.

Appendix A: <u>Dominance Type Definitions</u>

Shade Tolerant Species: IMIX

TGCH **T**olerant **g**rand fir, western red**c**edar and western **h**emlock

ABGR	grand fir
THPL	western redcedar
TSHE	western hemlock
TABR2	pacific yew (R1 FIA Summary Database)

TASH **T**olerant sub**a**lpine fir, **s**pruce and mountain **h**emlock

ABLA	subalpine fir
PIEN	Engelmann spruce
TSME	mountain hemlock

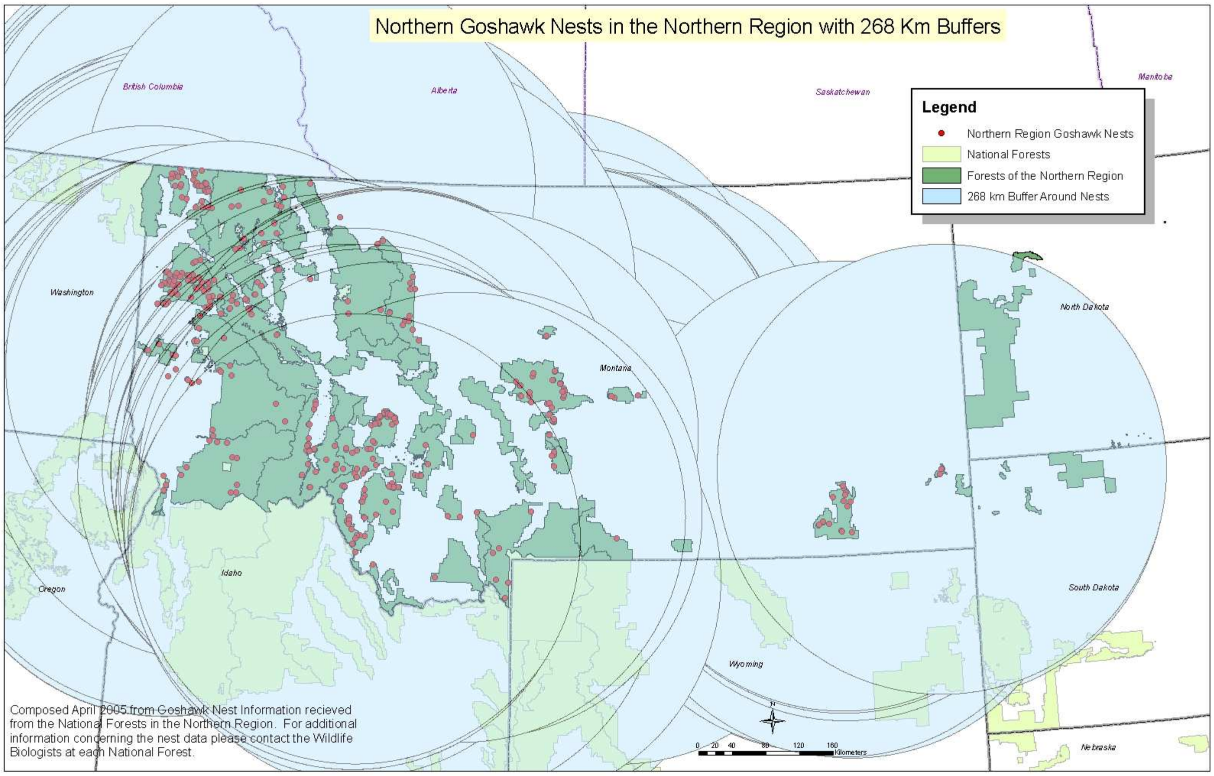
Shade Intolerant Mixed Species: IMIX

IMXS		**I**ntolerant **Mix**ed **S**pecies
	PIPO	ponderosa pine
	PSME	Douglas-fir
	LAOC	western larch
	LALY	alpine larch
	PICO	lodgepole pine
	PIMO3	western white pine
	PIAL	whitebark pine
	PIFL2	limber pine (this applies to summary program not the classifier program)
	POPUL	black cottonwood
	BEPA	paper birch
	POTR5	aspen
	JUNIP	juniper (this applies to summary program not the classifier program)

NOTES: 2TREE in Idaho is most likely TABR2. Therefore UNCL in the FVS Classifier is most likely TGCH in Idaho. In Eastern MT 2TREE could be PIFL2 or POTR5 or JUNIP or POPUL . Some discrepancies between summary database and stand classifier are due to: 1) rounding methods, 2) 2TREE classification, where FSV species is OS or OT, and 3) not having reporting rules when 2 or 3 species dominance types have = TPA or BA.

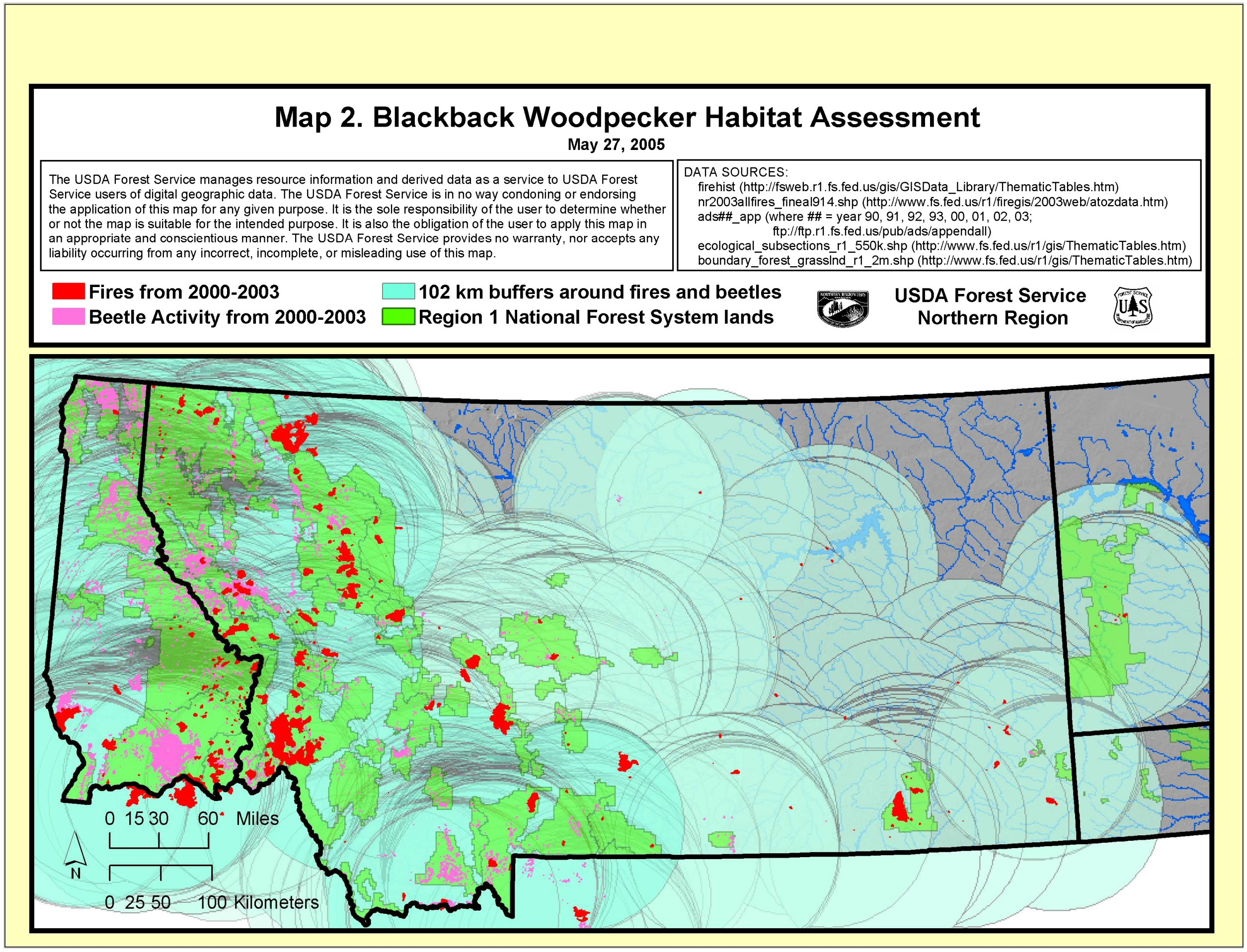
Appendix 7

Map of well-distributed habitat for the northern goshawk. A single population is evident in the Northern Region (see text for details).



Appendix 8

Map of well-distributed habitat for the black-backed woodpecker. A single population is evident in the Northern Region (see text for details).



Appendix 9

Species Habitat Estimates for the Idaho Panhandle National Forests

Forested Habitat

Number of FIA sample plots on the Idaho Panhandle National Forests (IPNFs) either by Ecological Subsection (Bailey 1996) or by 4th Code Hydrologic Unit (HUC) are shown in Table 25. The number of sample plots per Ecological Subsection or HUC reflects the size of area managed by the IPNFs.

Table 25. Number of sample plots in an Ecological Subsection (Bailey 1996) or 4th Code Hydrologic Unit (HUC) on the Idaho Panhandle National Forests.

Ecological Subsection	Number of sample plots	4th Code HUC	Number of sample plots
M333Aa	27	17010104	83
M333Ab	93	17010105	36
M333Ac		17010213	14
M333Ba	88	17000214	36
M333Be	5	17010215	62
M333Da	116	17010301	81
M333Db	101	17010302	13
M333Dd	26	17010303	4
M333De		17010305	117
		17060308	3
Total	456		456

The wildlife habitat relationship models developed for this conservation assessment represent three scales: 1) a Region-wide description where the full range of habitats used by a species is included in the model; 2) a Province-wide description where the full range of habitats used by a species within that particular Ecological Province is included; and 3) a Forest-specific model where local conditions are considered in the development of the habitat relationship model.

Table 26 summarizes the Region-wide, Ecological Province, and IPNFs wildlife habitat relationship models and describes any addition to the IPNFs models. A summary of habitat estimates based of each (Regional, Province, and IPNFs) model and for each of the four species also is included in Table 26.

Table 26. Habitat estimates based of each (Regional, Province, and IPNFs) model and for the four species. Differences in species-specific model by Region, Province or by Idaho Panhandle National Forests are displayed.

	R1 model	Province model	IPNFs 4th code HUC	IPNFs Ecological Subsection (Bailey 1996)	IPNFs model additions
Northern goshawk					
Nest	137,420	16,201	16,201	16,201	
PFA	145,225	58,132	57,007	57,007	
Foraging	376,266	381,193	292,251	292,251	Added = >23 cm ba_wt_dbh[1]
Flammulated owl					
Forest	33,602	13,342	7,795	7,795	Canopy coverage% of 40-70%; SE, S, SW, W, and LR aspect[2]; snag =>35 cm
Black-backed woodpecker					
Nest			606,125	606,125	FSVeg query only for IPNFs
Foraging			268,846	268,846	FSVeg query only for IPNFs
Pileated woodpecker					
Nest	175,349		172,833	172,833	
Foraging	296,377		291,651	291,651	

Table 26 continued				

[1] BA_WTD_DBH is the sum of the diameter of the tree times the number of trees the tree represents times basal area of the tree divided by total basal area.
[2] Southeast (SE), south (S), southwest (SW), west (W) and level rolling (LR).

Habitat Estimates—Northern Goshawk

Table 27 demonstrates abundant habitat for the northern goshawk on the IPNFs by Ecological Subsection (Bailey 1996). The size of an area that describes a northern goshawk nest site varies from 10 to 12 ha (Reynolds et al. 1992), therefore nest habitat exists on the IPNFs for upwards to 1350 nests or 270 to 675 pairs (assuming one to five alternative nests are constructed).

Table 27. Habitat estimates (ha) for the northern goshawk for the IPNFs by Ecological Subsection (Bailey 1996).

Subsection	Nest	Pfa	Foraging
M333Aa		1,135	17,587
M333Ab	1,737	11,587	46,930
M333Ac		110	
M333Ba	1,185		23,104
M333Be		1569	3,991
M333Da	4,949	15,528	124,957
M333Db	6,462	12,120	61,685
M333Dd	2,025		14,173
M333De			
Forest	16,201	57,007	292,251

Northern goshawk pfa (Table 27) habitat on the IPNFs would support upwards to 238 pairs, assuming a northern goshawk requires about 240 ha for a pfa (range is from 120 to 240 ha, Reynolds et al. 1991).

The northern goshawk foraging habitat relationship model was adjusted to include an additional structure requirement (>23 cm ba_wt_dbh, Table 26, R. Ralphs, personal communication, IPNFs, Coeur d'Alene, Idaho). Foraging habitat on the IPNFs (Table 27) could provide habitat for upwards to 166 pairs, assuming a northern goshawk requires 1758 ha for foraging (using an estimate of 1,758 ha for foraging and based on use of radio telemetry, Bright-Smith and Mannan 1994).

Table 28. Habitat estimates (ha) for the northern goshawk for the IPNFs by 4th Code Hydrologic Unit.

HUC	Nest	Pfa	Foraging
17010101			
17010103			
17010104		4,216	25,901
17010105	538	1,076	10,761
17010204			
17010213		584	9,929
17010214	593	2,964	20,745
17010215	1,804	9,623	40,297
17010216			
17010301	3,026	19,979	84,764
17010302	674		8,086
17010303	1,233	3,700	11,717
17010304	6,789	12,347	61,119
17010305	699	698	7,682
17010306			
17060308			
17060108			
17060306			
17060307			
17060308	1,041	2,082	12,496
Forest	16,201	57,007	292,251

A similar analysis using the northern goshawk wildlife habitat relationship models for nest site habitat, pfa and foraging (Table 26) but by 4th Code Hydrologic Unit (HUC) on the IPNFs is displayed in Table 28. Nest, pfa, and foraging habitat for the northern goshawk either by HUC or Ecological Subsection is abundant on the IPNFs.

Habitat Estimates—Black-backed Woodpecker

Black-backed woodpecker nest habitat was estimated by Ecological Subsection (Bailey 1996) (Table 29) and by 4th code HUC (Table 30) for the IPNFs. The black-backed woodpecker nest habitat relationship model estimates the amount of habitat with a snag => 12.7 cm/ha and less than five years since death. The literature suggests that snags remain a viable substrate for use by the black-backed woodpecker for at least five years as foraging habitat. It is assumed that the snag if of appropriate size could also serve as a nest cavity tree over a five year interval. The black-backed woodpecker is a primary cavity nester and excavates their own cavities most often

Table 29. Habitat estimates (ha) for the black-backed woodpecker for the IPNFs by Ecological Subsection (Bailey 1996).

Subsection	Nest	Foraging
M333Aa	39,713	14,183
M333Ab	121,096	50,986
M333Ac		
M333Ba	74,646	51,541
M333Be	9,978	2,494
M333Da	195,483	72,158
M333Db	127,487	59,336
M333Dd	35,095	17,548
M333De		
Forest	606,125	268,846

in dead or dying conifer trees (Short 1974, Raphael and White 1984, Weinhagen 1998, Martin and Eddie 1999).

Foraging habitat on the IPNFs by Ecological Subsection (Table 29) and 4th code HUC (Table 30) for the black-backed woodpecker was estimated by the amount of habitat with =>64 snags/ha and => 2.5 cm. Only lodgepole pine, larch and spruce snags less than five years since death were included in the estimate of foraging habitat.

The size of an area that describes a black-backed woodpecker territory varies from 72 ha to 124 ha (as cited in Dixon and Saab 2000 and in Hoyt 2000). The IPNFs provides forging habitat for upwards to 2,168 to 3,734 pairs and higher amount of nesting habitats (Table 29 and Table 30).

Table 30. Habitat estimates (ha) for the black-backed woodpecker for the IPNFs by 4th Code Hydrologic Unit.

HUC	Nest	Foraging
17010101		
17010103		
17010104	74,090	46,983
17010105	27,979	18,831
17010204		
17010213	21,027	8,177
17010214	52,755	21,339
17010215		

Table 30 continued		
17010216		
17010301	132,600	49,041
17010302	12,804	8,760
17010303	23,435	2,466
17010304	133,356	72,232
17010305	8,380	2,095
17010306		
17060308		
17060108		
17060306		
17060307		
17060308	24,992	3,644
Forest	606,125	268,846

Habitat Estimates—Flammulated Owl

Habitats for the flammulated owl on the IPNFs by Ecological Subsection (Bailey 1996) is summarized in Table 31 using the wildlife habitat relationship NRMEP (Table 17) model with three modifications (Table 26): 1) canopy coverage of 40-70%; 2) aspect of Southeast, South, Southwest, and West; and 3) a snag => 35 cm (R. Ralphs, personal communication, IPNFs, Coeur d'Alene, Idaho).

Table 31. Habitat estimates (ha) for the flammulated owl for the IPNFs by Ecological Subsection (Bailey 1996).

Subsection	Habitat
M333Aa	2,269
M333Ab	
M333Ac	
M333Ba	
M333Be	
M333Da	3,710
M333Db	1,762
M333Dd	
M333De	
Forest	7,795

Table 31. Habitat estimates (ha) for the flammulated owl for the IPNFs by 4th Code Hydrologic Unit.

HUC	Habitat
17010101	
17010103	
17010104	
17010105	
17010204	
17010213	584
17010214	1778
17010215	1,202
17010216	
17010301	1,209
17010302	674
17010303	616
17010304	1,234
17010305	
17010306	
17060308	
17060108	
17060306	
17060307	
17060308	520
Forest	7,795

Habitat by Ecological Subsection (Bailey 1996) for the flammulated owl on the IPNFs is displayed in Table 30. Given the small territory size [Linkhart et al. (1998) of 11.1 ± 1.9 ha in 1982 and 18.3 ± 5.1 ha in 1983], the IPNFs would provide habitat for upwards to 426 flammulated owl pairs. A similar analysis using the flammulated owl but by 4th Code Hydrologic Unit (HUC) on the IPNFs is displayed in Table 31.

Habitat Estimates—Pileated Woodpecker

The wildlife habitat relationships model for the Pileated woodpecker nest and winter foraging habitat (Table 26) estimates 7,795 ha for nest habitat and 291,651 ha for foraging habitat (Table 32 and Table 33) on the IPNFs.

In winter, most likely the critical period, the pileated woodpecker requires an area of 40 ha (Bonor 2001). In winter, the IPNFs may provide critical winter foraging habitat for upwards to

Table 32. Habitat estimates (ha) for the pileated woodpecker the IPNFs by Ecological Subsection (Bailey 1996).

	Habitat	
Subsection	Nest	Foraging
M333Aa	22,125	28,366
M333Ab	27,231	48,089
M333Ac		
M333Ba	8.886	23,697
M333Be	2,494	2,993
M333Da	70,520	121,865
M333Db	33,485	49,935
M333Dd	7,424	16,872
M333De		
Forest	172,833	291,651

Table 33. Habitat estimates (ha) for the pileated woodpecker for the IPNFs by 4th Code Hydrologic Unit.

HUC	Habitat	
	Nest	Foraging
17010101		
17010103		
17010104		16,263
17010105		11,299
17010204		
17010213	584	10,513
17010214	1778	29,637
17010215	1,202	54,732
17010216		
17010301	1,209	80,527
17010302	674	5,391
17010303	616	16,651
17010304	1,234	50,625
17010305		4,888
17010306		
17060308		
17060108		
17060306		

Table 33 continued		
17060307		
17060308	520	11,454
Forest	7,795	291,651

7,291 pairs of pileated woodpeckers. A similar pattern in abundant nest and wintering habitat for the pileated woodpecker on the IPNFs is evident by HUCs (Table 33).

Amounts of habitat

Table 34 compares estimated amounts of habitat for the four species considered in this assessment based both on Redmond et al. (2001) and this conservation assessment. In both estimates—the independent University of Montana Spatial Analysis Laboratory—and this conservation assessment, habitat is very abundant across the Northern Region and the IPNFs. As described in the main text (see also Appendix 7 and Appendix 8), well distributed habitat (1982 rule, 219.19) is not an issue.

Table 34. Habitat estimates (ha) (Redmond et al. 2001, this assessment) for the goshawk, black-backed woodpecker, flammulated owl, and pileated woodpecker on the Idaho Panhandle National Forests.

	Goshawk	Black-backed woodpecker	Flammulated owl	Pileated woodpecker
Redmond et al. (2001)	869,940	775,172	275,606	849,612
IPNFs models	292,251	268,846	7,795	172,833

Table 34 compares habitat amounts for the four species as estimated by Redmond et al. (2001) and by the IPNFs habitat relationship models (Table 26). In both cases (one independent and one by the Forest Service), habitat is very abundant for each of the four species. The differences in the species-specific estimates (Redmond et al. 2001 and this assessment) summarized in Table 34 reflect use of satelite-based information versus FIA. Only FIA may be used to estimate variables such as tree size, number of canopy layers, and tree density in conjunction with methodology such as bootstrap (Appendix 2 and Appendx 3). Use of satellite imagery should discuss possible errors (Beissinger and Westfall 1998) and or be limited to distinguishing forest and non-forest vegetation as in this conservation assessment.

Long-term viability and the sustainability of ecosystems reflect how ecological processes and native species interact (Figure 1, page 69) and form a "figure 8." The ecosystem cycle in Figure 8 represents a self-reinforcing system that maintains habitat within which species evolve and have depended upon for centuries to thousands of years.

The Idaho Panhandle National Forests will conduct an analysis of historic habitats and patterns in ecological processes that shape and sustain habitats important to wildlife (Haufler et al. 2002). This may result in loss of suitable habitat for the four species considered in this assessment in the short-term but will contribute to long-term sustainability (Representativeness, Redundancy and Resiliency) of their respective habitats, and therefore their long-term viability.

Appendix 10 Habitat estimates based on models developed as part of the Wildlife Counicil

Draft
Habitat Guidelines for the Black-backed Woodpecker
Northern Region, USDA Forest Service

Introduction

The purpose of this document is to provide project level habitat guidance for the black-backed woodpecker. This guidance represents both information in the published and unpublished (these and dissertations) scientific literature and expert opinion. The best available information used to develop the guidelines included peer-reviewed literature, unpublished literature (primarily theses and dissertations), and Region One assessment and inventory and monitoring data. Where necessary, habitat recommendations from other studies are adjusted to better reflect Region One conditions.

Major conclusions or information that form the basis for the guidelines includes the following.

1. Dixon and Saab (2000). *The Birds of North America No. 298* provides detailed information on breeding range, non-breeding range, migration, morphology, pair formation, courtship and copulation, nesting phenology, metabolism and temperature regulation, molts and plumages, and demographics.

2. US Forest Service Rocky Mountain Region black-backed woodpecker species assessment (http://fsweb.r2.fs.fed.us)

3. Hillis et al. (2002) produced an assessment of black-backed woodpecker habitat which evaluated the availability of fire-killed forests within the Northern Region. O'Connor and Hillis (2001) conducted a similar analysis for the Lolo National Forest in 2001. These analyses compared historic amounts of post fire habitat to existing amounts which is often referred to in concept as the Historic Range of Variability.

4. Samson (2006) provided a conservation assessment which provides a summary of published and unpublished literature that describes habitat use by the black-backed woodpecker and estimates habitat available by Forest.

5. Life history—Montana Natural Heritage Program (http:/nhp.nris.state.mt.us/mbd) and Idaho Digital Atlas (http://imn.isu.edu/digitalatlas).

6. Status—the black-backed woodpecker is neither threatened nor endangered, and has never been petitioned for listing. The black-backed woodpecker has a global conservation status rank of G5 – demonstrably widespread, abundant and secure (www.natureserve.org).

7. Population trend—an analysis of Breeding Bird Surveys (http.//www. mbr-pwrc.usgs.gov) for 1966–1996 indicates a significant increase (6.7% change/year) in black-backed woodpecker populations in spruce-hardwoods (n = 26) BBS survey routes, a significant increase (6.6% change/yr) in the United States (n = 27) BBS survey routes, and no significant population trend elsewhere (Sauer et al. 1997). No route from 1966 to 2004 in the BBS database shows a long term decline for black-backed woodpecker (Sauer et al. 2005).

Principle Habitat Recommendations

● Background

Understanding habitat requirements for the black-backed woodpecker in the northern Rocky Mountains and elsewhere is limited due to study design (Hoffman 1997). Few studies have equally sampled all habitats and seral stages in proportion to their availability on the landscape. For example, Ibarzabal and Desmeules (2006) tested the hypothesis that the probability of detection in burned and unburned forests was similar. They found the time to detect black-backed woodpeckers in burned forest (3 minutes) was significantly (p<.0001) different from the time required (25 minutes) in unburned forest. This suggests that surveys for the black-backed woodpecker must adjust the length of time at a survey sample point to reflect differences in habitat.

Three possible causes exist to explain black-backed woodpecker distribution and abundance in the Northern Region: 1) use of post-burn areas; 2) use of insect outbreak areas; and 3) a pattern expected in a landscape with a natural range in the occurrences of ecological processes such as fire and insect use. All three premises assume a close relation to the spatial and temporal distribution and abundance of bark beetles and or wood-boring beetles.

<u>Post-burn habitat</u>. Lester (1980) examined the relationship of five woodpeckers and an endemic population of mountain pine beetles. Woodpeckers were observed to both feed and nest in post-fire areas. Harris (1982) in a study in a post-fire area near Missoula, Montana showed Picoides to be present although a decline occurred three years post-fire. This concentration of Picoides woodpeckers was in response to bark beetles and wood-boring beetle larvae in the fire-damaged trees. In this study, many lodgepole pines were attacked by mountain pine beetles but the short-term nature of the study precluded establishing consistent predictors of woodpecker densities.

In the summers of 1992-1994, Caton (1996) surveyed birds in the Red Bench post-fire area in northwestern Montana. Most of the burn area consisted of lodgepole previously killed by mountain pine beetles but included patches of Douglas-fir, Engelmann spruce, subalpine fir, western larch, ponderosa pine and other tree species. Additional transects in bordering unburned stands of 80-year old lodgepole pine were established for comparative purposes.

Caton (1996) found 12 black-backed nests in the post-fire area with cavities excavated in two tree species (Table 11). Caton (1996) did note (page 31) that large fires, i.e., the Red Bench in the study area, were not common historically (before Euro-Americans) in her study area and that fire suppression "may have serious consequences for the black-backed woodpecker" (page 31).

Caton's study showed that food availability and not nest site availability was limiting use of post-fire areas by both the black-backed woodpecker and the three-toed woodpecker.

Hutto (1995) estimated bird abundance in 34 burn sites in the northern Rocky Mountains following the 1988 forest fires (one fire in 1987). These data were compared to bird-count data in other vegetation types. Hutto (1995) found an abundance of black-backed woodpeckers and they seemed to be nearly restricted in distribution to post-burn habitats. Murphy and Lehnhausen (1998) expanded on Hutto's observations, and suggested recently burned forests represented "source habitats," i.e., population numbers may increase in post-fire and decrease when occupying other and unburned forests.

More recently, in a series of studies (http://www.rmrs.nau.edu/lab/4251/birdsburns), Saab reports that the black-backed woodpecker:

1) nested in areas with significantly higher snag densities (101/acre) and larger trees (15.8 inches) than non-nest areas in Idaho post-burn forests;

2) odds of nest occurrence doubled with an increase of 2 snags/acre;

3) preferred ponderosa pine (nearly 2:1) over Douglas-fir;

4) had greater odds (nearly 3:1) of the nest in unlogged versus logged area;

5) for every 20 acres increase in patch size, odds of nesting increased 1.2 times;

6) nest success was higher in post-burn than beetle-killed forest; and

7) nesting numbers peaked 4 years post-fire.

The favorable effects of fire are not long lasting for either the bark beetle or the wood-boring beetle. Partially burned trunks and roots may provide habitat for the bark beetle for up to 10 years after burning (Werner 2002). The limiting factor for the wood-boring (Cerambycidae and Buprestidae) is the moisture content of the wood. Insect development and survival decreases as trees dry out in four to eight years after fire depending on location (Werner and Post 1985). Population levels of wood boring drop to levels below nearby undisturbed sites when post-fire areas change and dry over time. Partially burned areas near the perimeter of intensively burned sites provide habitat for diverse assemblages of wood-boring beetles.

<u>Bark beetle infested habitat</u>. Areas of bark beetle (Scolytidae) infestation have received less attention in terms of research on black-backed habitat than post-burns areas. Bull et al. (1986) and Goggans (1988) report nesting of black-backed woodpeckers in areas of bark beetle outbreaks in Oregon. Setterrington et al. (2000) proposed populations of black-backed woodpeckers could be supported by endemic localized populations of bark beetles, as Hughes suggested (2000) in northeastern California.

Mohren (2002: 87) in his study of the black-backed woodpecker in the Black Hills of South Dakota concluded “It is also possible these woodpecker species are not selecting foraging location based on habitat characteristics, but are selecting areas populated with wood-boring beetles.” Mohren (2002) criticized management recommendations in the Black Hills Forest plan (1996 Revised Land Resource Management Plan Final Environmental Statement III-450) that call for thinning in that such timber management would reduce habitat suitable for insect outbreaks and, therefore, habitat for the black-backed woodpecker.

Mohren (2000: 86, 87) further suggested a need to create “stands that will become susceptible to wood-boring beetles will provide an abundance of prey for both of these species (black-backed and three-toed woodpeckers) as part of forest management by the Black Hills National Forest. Also, allowing large areas to become infested with wood-boring beetles (such as Baer Mountain area) is suggested to let black-backed and three-toed woodpeckers increase in population size. Current outbreaks should be examined to determine the effects wood-boring beetles have on black-backed and three-toed woodpecker.”

Bonnot (2006) also working in the Black Hills with support from the US Forest Service found black-backed woodpeckers nested in areas of mountain pine beetle and preferred areas with increased snag densities. Bonnot found black-backed woodpecker nest success in bark beetle areas ranged from 75% (n =1 2 in 2004) to 47% (n = 32 in 2005) and used both live and dead aspen trees on an equal bases. He further suggested that black-backed woodpecker demographics in bark beetle habitat were at least equal to that reported in post burn habitat. Bonnot (2006: 2) further suggested that forest managers "will need to consider trade-offs between timber harvest and wildlife species that benefit from mountain pine beetle infestations."

A natural range. Mohren (2002) suggested that historically small but widespread outbreaks of wood-boring beetles in a natural landscape could support black-backed woodpecker populations. R. Dixon (2005, personal communication, Idaho Fish and Game, Boise) also suggests the black-backed woodpecker may be neither dependent on either post-fire or insect outbreaks but may be well distributed but relatively uncommon in the more natural landscape.

As noted by Hoyt and Hannon (2002), few studies have considered all habitats in proportion to availability nor considered the comparative difficulty in observing birds in open post-fire habitats versus the more closed and structurally complex live forest environment.

Hoyt and Hannon (2002) found black-backed woodpeckers nesting in stands of old spruce 46 to 93 miles distant from the post-fire study, suggesting ability for the black-backed woodpecker to survive in non-post fire areas. Hoyt (2000: 34) further notes “to assess the source-sink dynamics of recently burned and oldgrowth black spruce habitats estimates of fecundity and survival would be required.” Hoyt’s sample size (n = 22 nests) was inadequate to estimate either fecundity or survival rates to estimate source-sink dynamics. Hoyt (2000: 34) continued with “I believe that with an intensified search effort it would be possible to find nests in unburned forests (see Weinhagen 1998). Therefore, I believe that oldgrowth black spruce sites embedded in a matrix of old forests need to be examined more closely before they can be classified as sink habitat.” Tree mortality due to the mountain pine beetle can occur as scattered individual trees well distributed across the landscape or may impact entire groups of trees.

● Landscape

Managing at a landscape level may be important for those species which may or are suggested to respond to features of the landscape such as beetle outbreaks and fire that change over space and time in location. One issue in managing for species such as the black-backed woodpecker is how much of the landscape is needed to maintain the species particularly in areas of salvage logging. Unfortunately, data are few to provide guidelines between levels of timber harvest and ecological consequences (Hutto 2006).

One approach to conservation including that of the Forest Service is to use the Range of Natural Variation (RNV). The primary assumption in RNV is that the array of historic community types and their distribution within their expected range is adequate to maintain the viability of the majority of species (Samson 2002). Understanding natural pattern in fire is on the increase in the Northern Region but published examples that describe the historic landscape are few (Gallant et al. 2003). If estimates of the historic landscape extent and composition are available, one could suggest based on a review of the literature (Fahrig 2003) that persistence of species associated with a habitat type (i.e., post-fire or beetle outbreak) is vulnerable when a threshold of 20-30% of historic is reached. Important assumptions include that neither pre- or planned management actions have an affect and variation in habitat quality is minimal.

In the Northern Region, mean number of live trees/acre (>5 inches—a size considered large enough to remain standing following fire) range from 145 on the Custer NF to 252 on the Beaverhead-Deerlodge NF. Mean number of standing dead trees in the Northern Region range from 22.4/acre on the Clearwater NF to 44.9 on the Gallatin NF. Conceptually, following fire, it would be possible to have upwards to 275 snags/acre on a National Forest assuming dead trees survive fire—a more likely upper general bound would be 145 to 230/acre.

Research indicates that habitat use by the black-backed woodpecker varies greatly (Table 1) varied other than selecting relatively small trees for nest cavities. Nevertheless, in areas salvage logging of post-fire or beetle kill trees areas, the following is recommended as a minimum.

1. Maintain 30% of post-fire or beetle kill trees areas by 6th code or larger hydrological unit as identified through a RNV analysis. This would be a conceptual minimum required for persistence—a higher percent would be better conservation. Minimum amounts of either post-burn or beetle infested habitat to permit nesting are unknown.

2. Meet Forest Plan guidelines for snag numbers and distributions. If Forest Plan guidelines for snag numbers and distributions are not available, provide upwards of 5 live trees/acre for nesting and 20 snags/acre (Table 1) depending on the natural pattern on vegetation in the treatment area.

Table 1. Summary of black-backed woodpecker nest, nest area, and foraging habitat.

Habitat Feature	Key Components	Bull et al. 1986[1]	Harris 1982[2]	Groggans et al. 1989[3]	Mohen 2002[4]	Saab 2006[5]	Bonnot 2006[6]	Taylor and Schachtell 2002[7]	Range of Conditions

es									
Nest	Live Trees/ac	2	2	8.9	-	-	5.6	-	mid-point 5, range 2 - 9
	Dead Trees/ac	4	14	4.9	2.8	101	13	2.4	mid-point 20, range 2 - 101
	Size (inches)	11.81 +- 2.72	9.19 +- 1.11	7.87	15.75	15.75 +-0.79	Conifer – 10.81+-1.57 Aspen – 7.85+-0.84	10.12	8-16
	Cover	-	-	Multi	68.9%	-	-	-	Multi
	Basal Area	-	-	-	-	-		-	-
Nest Area	Live Trees/ac	17 +- 16.5	-	-	-	-	32	-	≥ 17
	Dead Trees/ac	18 +- 18.1	-	-	-	-	-	-	≥17
	Size (inches)	-	4.9 +- 0.39	-	-	-	-	-	> 5
	Cover (%)	46%	-	-	-	-	28+-18.59%	-	28-46
	Basal Area	20 +- 11.9	-	-	-	-	-	-	-
Foraging	Live Trees/ac	-	-	-	-	-	-	-	-
	Dead Trees/ac	-	-	-	1.9	129+-9.7	-	23+-12.6	23 - 129
	Size (inches)	-	-	-	9.49	-	-	1	≥ 1
	Cover	-	-	-	-	-	-	-	-
	Basal Area	-	-	-	-	-	-	-	-

[1] Bull et al. (1986) study area in Oregon.
[2] Harris (1982) study area near Missoula, Montana.
[3] Groggan et al. (1989) study area on the Deschutes National Forest in Oregon.
[4] Mohen (2002) study area in the Black Hills, South Dakota.
[5] Saab (2006) study areas in Idaho, South Dakota, and Montana.
[6] Bonnot (2006) study area in the Black Hills, South Dakota.
[7] Taylor and Schachtell (2002) analysis area on the Idaho Panhandle National Forest.

3. Moderate and high intensity burned forest areas as well as areas of bark beetle infestation may be used for nesting habitat. Moderate and high intensity post-fire areas may be suitable for up to 10 years. Habitat quality is better 1 – 4 years following fire.

4. In potential burn areas, patch size (bigger better) and pre-fire crown closure (>50%) is a predictor of post-fire habitat use—probably reflects future snag densities.

● Nest Area

Recommendations as to the minimum stand size are not available but should exceed that required to maintain a pair (29 to 50 acres, Dixon and Saab 2000). Stand composition habitat recommendations are difficult do to the variation in data that describe nesting conditions other than nest tree size (Table 1). The Range of Conditions are recommended based on available scientific literature and information is recommended to described black-backed woodpecker habitat. Two variable [nest tree size (8 to 16 inches) and number of snags/acre (>18/acre)] are used in the updated Conservation Asessment (Samson 2006) to estimate Ecological Province and Forest habitat amounts.

● Project analysis

1. All Forest Plan standards are met and documented.

2. Analysis is disclosed in the NEPA document that considers and discusses the quality and quantity of habitat necessary to support the black-backed woodpecker utilizing available scientific habitat recommendations.

3. Considers and discloses any known black-backed woodpecker population information, data or trend information available from monitoring sources, natural history databases etc.

4. Sets forth and applies a methodology for measuring the existing amount of the species habitat. The methodology used is supported by evidence that the methodology is reasonably reliable and accurate with reference to scientific and other sources relied upon.

5. Considers and discusses the amount of species habitat available at the Regional and/or Forest-wide level (Samson 2006).

6. Discloses the impact of the project on the species habitat based on the above—including cumulative impacts—showing that no appreciable adverse habitat disturbance would result from the planned activity. The basis for the Forest Service's conclusion is adequately explained with reference to the factual basis for its analysis.

7. Addresses and includes discussion of any scientific uncertainty or credible opposing scientific viewpoints raised in public comment concerning habitat recommendations, methodologies etc.

During project level planning, it may be necessary to determine the presence of black-backed woodpeckers to determine whether activity restriction or habitat recommendations should be applied. The presence of black-backed woodpeckers can be determined by reviewing District/Forest/Grassland wildlife sighting records, reviewing District/Forest/Grassland wildlife monitoring records, and/or conducting field inventories for black-backed woodpeckers within the project area. Such information should be availble in FAUNA.

See attached checklist for consistency

Summary

Understanding habitat requirements for the black-backed woodpecker in the northern Rocky Mountains and elsewhere is limited. Few studies have equally sampled all habitats and seral stages in proportion to their availability on the landscape. Data are available to describe over 300 nest tree sizes, less information exists on nest stand or foraging habitat. Three possible causes exist to explain black-backed woodpecker distribution and abundance in the Northern Region: 1) use of post-burn areas; 2) use of insect outbreak areas; and 3) a pattern expected in a landscape with a natural range in the occurrences of ecological processes such as fire and insect use. All three premises assume a close relation to the spatial and temporal distribution and abundance of bark beetles and or wood-boring beetles. Forests are encouraged to use local information if available to adjust habitat recommendations summarized in Table 1 and as outlined under Project Analysis.

Literature Cited

Bonnot , T.W. 2006. Nesting ecology of black-backed woodpeckers in mountain pine beetle infestations in the Black Hills, South Dakota. Thesis, University of Missouri, Columia, USA.

Bull, E. L., S. R. Peterson, and J. W. Thomas. 1986. Resource partitioning among woodpeckers in northeastern Oregon. USDA Forest Service Research Note PNW-444.

Caton, E. L. 1996. Effects of fire and salvage logging on the cavity-nesting bird community in northwestern Montana. Dissertation, University of Montana, Missoula, Montana, USA.

Dixon, R. D., and V. A. Saab. 2000. Black-backed woodpecker (*Picoides arcticus*). No. 509. In Birds of North America. A. Poole, and F. Gill, editors. The Academy of Natural Sciences, Philadelphia, Pennsylvania, and The American Ornithologists' Union, Washington, DC, USA.

Fahrig, L. 2003. Effects of habitat fragmentation on biodiversity. Annual Review of Ecology and Systematics 34: 487-515.

Gallant, A., A. J. Hansen, J. S. Councilman, D. K. Monte, and D. W. Betz. 2003. Vegetation dynamics under fire exclusion and logging in a Rocky Mountain watershed. Ecological Applications 13: 385-403.

Goggans, R. 1986. Habitat use by flammulated owls in northeastern Oregon. Master's thesis, Oregon State University, Corvallis, Oregon, USA.

Harris, M.A. 1982. Habitat use among woodpeckers in forest burns. Master's thesis, University of Montana, Missoula, Montana, USA.

Hillis et al. 2002

Hutto, R .L. 1995. Composition of bird communities following stand replacement fires in Northern Rocky Mountain (U.S.A.) conifer forests. Conservation Biology 9: 1041-1058.

Hoffman, N. J. 1997. Distribution of Picoides woodpeckers in relation to habitat disturbance within the Yellowstone area. Master's thesis, Montana State University, Bozeman, Montana, USA.

Hoyt, J. S. 2000. Habitat associations of black-backed *Picoides arcticus* and three-toed *P. tridactylus* woodpeckers in the northeastern boreal forest of Alberta. Dissertation, University of Alberta, Edmonton, Alberta, Canada.

Hoyt, J. S, and S. J. Hannon. 2002. Habitat associations of black-backed and three-toed woodpeckers in the boreal forest of Alberta. Canadian Journal of Forest Research 32: 1881-1888.

Hughes, K. K. 2000. Foraging ecology of Picoides woodpeckers in relation to ponderosa pine decay dynamics. Master's thesis, University of Idaho, Moscow, Idaho, USA.

Hutto, R .L. 1995. Composition of bird communities following stand replacement fires in Northern Rocky Mountain (U.S.A.) conifer forests. Conservation Biology 9: 1041-1058.

Ibarzabal, J., and P. Desmeules. 2006. Black-backed woodpecker (*Picoides arcticus*) in unburned and burned mature conifer forests in north-eastern North America. Annuals Zoological Fennica 43: 228-234

Lester, A. M. 1980. Numerical response of woodpeckers and their effect on mortality of mountain pine beetles in lodgepole pine in northwestern Montana. Master's thesis, University of Montana, Missoula, Montana, USA.

Mohren, S. R. 2002. Habitat evaluation and density estimates for the black-backed woodpecker (*Picoides arcticus*) and three-toed woodpecker (*Picoides tridactylus*) in the Black Hills National Forest. Master's thesis, University of Wyoming, Laramie, Wyoming, USA.

Murphy, E. C., and W. A. Lehnhausen. 1998. Density and foraging ecology of woodpeckers following a stand-replacement fire. Journal of Wildlife Management 62: 1359-1372.

O'Connor and Hillis 2001

Samson, F. B. 2002. Population viability analysis: management, and conservation planning at large scales. Pages 425-441 *in* Population viability analysis. S. R. Beissinger, and D. R. McCullough, editors. University of Chicago Press, Chicago, Illinois, USA.

Samson, F. B. 2006a. (www.fs.fed.us/r1/projects/wlfecology; Accessed June 29, 2006). A Conservation assessment of the northern goshawk, blacked-backed woodpecker, flammulated owl, and pileated woodpecker in the Northern Region, USDA Forest Service. Unpublished report on file, Northern Region, Missoula, Montana, USA.

Sauer, J. R., J. E. Hines, and J. Fallon. 2005. The North Amerian Breeding Bird Survey 1966-2005, Version 6.2. US Geological Survey Patuxent Wildlife Research Center, Laurel, Maryland, USA.

Setterington, M., I. D. Thompson, and W. A. Montevecchi. 2000. Woodpecker abundance and habitat use in mature balsam fir forests in Newfoundland. Journal of Wildlife Management 64: 335-345.

Taylor, J., and E. Schachtell. 2002. Black-backed woodpecker habitat analysis of six Idaho Panhandle National Forest at two scales. Unpublished mimeo on file, Idaho Panhandle National Forests, Coeur d' Alene, Idaho, USA.

Weinhagen, A. C. 1998. Nest-site selection by the black-backed woodpecker in northeast Vermont. Master's thesis, University of Vermont Burlington, Vermont, USA.

Werner, R. A. 2002. Effect of ecosystem disturbance on diversity of bark and wood-boring beetles. USDA Forest Service Research Paper PNW-546, Portland, Oregon, USA.

Werner, R. A., and K. E. Post. 1985. Effects of wood-boring insects and bark beetles on survival and growth of burned white-spruce. Pages 14-16 *in* Early results of the Rosie Creek fire research project-1984. Agricultural Experiment Station Publication 85-2, University of Alaska, Fairbanks, Alaska, USA.

DRAFT Terrestrial Wildlife Consistency Checklist

	√	Topic	Yes	No	NA	Notes
1		Have you determined the probability of occurrence of wildlife species and/or their habitat in the project area?				
2		Does habitat for the relevant species occur both, in the analysis area and on the Forest?				
3		Has the species been detected both, in the analysis area and on the Forest?				
4		Does the species have special status? (TES, SOCI, MIS)				
5		Has the species been involved in past or ongoing litigation? Have you reviewed the results of this litigation?				
6		How was species occurrence determined? (Historical or Hard evidence)				
7		Has a Regional conservation or viability assessment been completed for the species?				
8		Has the species been addressed in the state comprehensive wildlife conservation strategy (CWCS)?				
9		Have conservation assessments and/or state CWCSs identified conservation needs, and addressed current or predicted trends in the species habitat and/or populations?				
10		Is there a current or predicted trend in habitat capability on the unit?				
11		Are habitat conclusions in conservation assessments and/or state CWCSs consistent with FIA data or other broad-scale tools?				
12		Have you defined the methods used to determine habitat conditions?				
13		Have you assessed the age of data available for use in assessing the species and habitat?				
14		Are the species' habitat parameters understood and consistently applied on the unit?				
15		Have you assessed habitat conditions at a sufficient scale to determine direct, indirect and cumulative effects?				
16		Have you explained why your analysis area is sufficient?				
17		Have you identified all the past, present				

		and foreseeably future actions that affect habitat or the species?				
18		Does the proposed action and alternatives provide sufficient information to assess potential impacts to species habitat?				
19		What types and amounts of habitat are affected by the project?				
20		Are the types and amounts of habitat in short supply in the analysis area and/or unit? If so why?				
21		Have the potential effects been listed and described?				
22		Have you described whether the effects are permanent, temporary or seasonal? Have you described why and for how long?				
23		Have the effects to species habitat been put into context? Have you disclosed the percentage of the suitable habitat that is being affected in the analysis area and on the forest?				
24		Have habitat-based design criteria been incorporated into the proposed action or an alternative?				
25		Are mitigation measures needed above and beyond project design criteria?				
26		Do the habitat evaluations, project effects and determinations track consistently through the assessment process?				
27		Have you made a final effect determination? Have you used the appropriate determination language?				
28		Have you clearly stated the rationale for the determination?				
29		Has the best available science been used and documented in the project record?				
30		Has opposing science been used and documented in the project record?				
31		Has scientific uncertainty been addressed in the assessment?				

A more detailed explanation/description of these checklist topics is contained in the project record.

Definitions: *Probability of Occurrence* – Low = No evidence of, or potential for the species or habitat. Species is not relevant to the project; Moderate = Evidence of, or potential for the species or habitat; High = Species reproductive sites are known. Moderate and High probability species are relevant to the project.
Habitat capability – The ability of a specified area to support a species expressed in terms of numbers of animals and/or amount of suitable habitat.

Habitat Estimates for the black-backed woodpecker using the model described above (i.e., Table 1).

Forest	Habitat (ha)
Beaverhead-Deerlodge	170,698
Bitterroot	42,560
Idaho Panhandle	426,936
Clearwater	195,619
Custer	28,703
Flathead	55,539
Gallatin	119,519
Helena	47,459
Kootenai	89,503
Lewis and Clark	92,856
Lolo	105,255
Nez Perce	298,226

DRAFT
Habitat Guidelines for the Northern Goshawk
Northern Region, USDA Forest Service

Introduction

The Northern Region has three approaches to goshawk conservation: 1) summarize the best available information and estimate amounts and distributions of goshawk habitat (Samson 2006a and 2006b); 2) use a grid-based peer reviewed (Woodbridge and Hargis 2006) sampling framework that allows for estimation of detection probabilities to estimate goshawk occurrence (Kowalski 2006); and 3) provide consistent activity and habitat guidelines at the project scale.

This document provides management guidelines for northern goshawk during project level analyses to protect adults and their young during the breeding season as well as to sustain habitat over time at spatial scales that are biologically meaningful (nest area, post fledging area, and foraging area, detailed below). The best available information was used to develop the guidelines, including peer-reviewed literature, unpublished literature (primarily theses and dissertations), and Region One assessment and inventory and monitoring data. Where necessary, habitat recommendations from other studies were adjusted to better reflect Region One conditions.

Major conclusions that form the basis for the guidelines include the following:

1. No demographic information exists to suggest a decline in goshawk numbers (USDI Fish and Wildlife Service 1998, Kennedy 2003, Anderson et al. 2004, Squires and Kennedy 2006).

2. Goshawk population growth rate is influenced by density-dependent territoriality (Reich et al. 2004). Food availability (Salafsky et al. 2005) and lack of predation characterize high quality habitat (Squires and Kennedy 2006).

3. Goshawk habitat in Region One is abundant and well distributed where it occurs naturally, and more forest, and therefore nesting habitat, exists on today's landscape than what occurred historically (Samson 2006a).

4. One would expect with a high level of confidence (95%) that 39% +- 10% of road-accessible habitat of all quality in Region One should have goshawks present during the breeding season (Kowalski 2006). The estimate is based on a simple, one-year, random sample (n=114) of 12,350 sampling units located in road-accessible habitat in Region One that were surveyed for goshawk presence in 2005 following Woodbridge and Hargis (2005). Methods, results, management implications and cautions are summarized in Kowalski (2006).

5. Relevant spatial scales: Relevant habitat variables from Forest Inventory and Analysis (FIA) plot data were used to model and estimate nesting and post fledging area (PFA) habitat by National Forest in each of three ecological provinces that encompass Region One; the

Northern Rocky Mountain Steppe, Middle Rocky Mountain Steppe, and Southen Rocky Mountain Steppe (Bailey 1996 *in* Samson 2006a). We recognize that FIA data provides statistically reliable estimates at the regional and forest levels down to around the 5th field hydrologic unit code level. The data is useful when analyzing cumulative effects for a project, but cannot be spatially displayed. As a result, finer scale vegetation data, such as TSMRS or FSVeg, are necessary to quantify and map goshawk habitat at the project level, using variables or combinations of variables similar to those used in the FIA models.

6. Principle habitat attributes in the nest, PFA, and foraging areas:

   a. Nest Area.

      i. Goshawks nest in a variety of forest types throughout their range (i.e. Squires and Reynolds 1997, USDI Fish and Wildlife Service 1998, Samson 2005, Squires and Kennedy 2006).
      ii. In general, the nest area vegetation is described by a narrower range of characteristics: mature forests with larger trees; relatively closed canopies; and open understories (*Ibid.*).
      iii. Average patch size of the core nest area varies based on available habitat conditions, i.e. 30 acres recommended by Reynolds et al. 1992 in the southwestern United States, 40 acres found by Clough (2000) in west central Montana, 74 acres found by McGrath et al. (2003) in northeastern Oregon and central Washington, and 80 acres found by Patla (1997) in Idaho.
      iv. No evidence exists that the goshawk is dependent on large, unbroken tracts of “old growth” or mature forest (Federal Register 63: 35183, June 29, 1998) or selects for "oldgrowth" forest (Whitford 1991, McGrath et al. 2003).
      v. Forest management may have either a positive or negative impact on goshawk nesting habitat (Squires and Kennedy 2006). However, 14 years of data collected from the southwestern United States show that a number of factors, including weather, predators, competitors, and disease, significantly confound the detection of forest management effects on goshawk reproduction (Reynolds et al. 2005). Limited data suggest that goshawks in shelterwood systems in France and Italy may be able to tolerate some vegetation treatments around nest areas down to some threshold (Penteriani and Faivre 2001). Furthermore, McGrath et al. (2003 @ p.24) found goshawks in central Washington and northeastern Oregon (n=82) occurred closer to human disturbances (i.e. forest roads) compared with random sites (P=0.054), with productivity levels well within the ranges reported for studies in managed and unmanaged landscapes throughout the western United States.
      vi. More than habitat composition or any other factor (i.e. prey abundance), territoriality determines nest distribution, and spring weather determines nest success (Joy 2002, Reich et al. 2004).

   b. *Post-fledging area.*

      i. The function of the goshawk PFA is unknown but is defended unlike the foraging area. The PFA may provide protection from predation and serve as an area where young birds develop flying and hunting skills (Reynolds et al. 1992, Kennedy et al. 1994).

ii. Size (148 to 420 acres), shape and habitat composition of the PFA may vary with local conditions (*Ibid*.).

c. *Foraging areas*.

i. Goshawk foraging areas are heterogeneous and may include some mature forest components (Squires and Kennedy 2006) as well as a mix of other forest and non-forest components (i.e. sagebrush, grasslands, lowland riparian, and agriculture) (i.e. Younk and Bechard 1994, Reynolds 1994, Patla et al. 1997).

ii. Size of the typical home range for the goshawk varies depending on a number of factors (1409 to 8649 acres) (Kennedy 2003).

iii. The composition of vegetative types, including tree canopy closures and size class distributions located outside the nest area blend into the surrounding landscape beyond the PFA scale, such that, no difference in habitat composition in occupied versus random foraging areas can be detected (McGrath et al. 2003).

Project Habitat Recommendations

● Nest stand

Activity

Maintain a minimum 40 acre (see below) no activity buffer placed around known goshawk nest trees occupied at least once in the past 10 years (Reynolds et al. 2005, Woodbridge and Hargis 2006) to maintain existing conditions in all or a portion of the nest area. Patch shape and size of the buffer may vary depending on topography or other local conditions (such as multiple alternate nests found in close proximity to one another). No activity means no ground disturbance or vegetation manipulation may occur at any time inside the buffered nest area, until the nest area is no longer used by the breeding pair. The no activity buffer was selected to conserve existing conditions in the core nest area (see 6.a.iii. above) because desired conditions are assumed present around recently-occupied nest areas; and it errs on the conservative side until conclusive, empirical data on the effects of thinning in nest areas in close proximity to nest trees is available.

Habitat

The following are desired conditions for nesting habitat that may vary by Ecological Province, fire history, insect activity or other local factors (Samson 2005: Table 6). Maintain at least 240 acres of suitable nesting habitat in known or potential goshawk territories in patches of at least 40 acres where feasible (adjusted from Reynolds et al. 1992 to reflect Region One conditions).

<u>Northern Rocky Mountain Ecological Province (including the Idaho Panhandle, Kootenai, Flathead, Lolo, Bitteroot, and Clearwater National Forests).</u>

Tree dominance group: Grand fir, larch, western white pine, ponderosa pine, lodgepole pine, Douglas-fir, hemlock mix, western hemlock, aspen, and birch.Tree size: 14 +- 3.8 inches
Canopy cover: 79.8 +- 12.2%

Basal area: 181 +- 65.7 square feet/acre
Structure class: 1 (one-story), 2 (two-story)

Middle Rocky Mountain Province (including the Beaverhead-Deerlodge, Helena, Lewis and Clark, and Nez Perce National Forests)

Tree dominance group: Grand fir, larch, western white pine, ponderosa pine, lodgepole pine, Douglas-fir, hemlock mix, western hemlock, aspen, and birch
Tree size: 15.4 +- 2.5 inches
Canopy cover: 52.4 +- 18.2%
Basal area: 187 +- 65.7 square feet/acre
Structure class: 1, 2

Southern Rocky Mountain Province (including the Custer and Gallatin National Forests)

Tree dominance group: Lodgepole pine, Douglas-fir, ponderosa pine, and aspen
Tree size: 12.5 +- 3.0 inches
Canopy cover: 70.0 +- 10.3%
Basal area: 142 +- 38.3 square feet/acre
Structure class: 1, 2

● Post fledging area

Activity

A 297-acre (Reynolds et al. 1992) no activity buffer from 15 April through 15 August around a nest, currently active or was active the previous year, to protect the goshawk pair and young from disturbance during the breeding season until fledglings refine flying skills. After August 15, treatment-related activities may commence within the PFA.

Habitat

Table 1 provides a range of conditions for habitat composition found in PFAs in the western United States showing the variation found among geographic regions, depending on Ecological Province, fire history, insect activity or other local factors. Note McGrath et al. (2003) quantified the composition of the PFA by seral stage. These seral stages were combined and placed into one of three tree size classes plus openings, to best match the nomenclature used by the Northern Region including, seedling/saplings (< 5" dbh), pole-sized (5 to 8.9" dbh); mature and older forest (> 9" dbh), and openings (wet/dry combined). Table 1 also displays the proportion of PFAs with greater than 50% canopy cover [6]. A canopy coverage >=50% is suggested for Forests in the Middle and Southern Rocky Mountain Ecological Provinces; >=70% for the Northern Rocky Mountain Ecological Province (Samson 2006a). The last column displays the range of mean conditions found among the studies.

Table 1. Range of conditions for habitat composition found in post fledging areas (PFAs) in the western United States. Data reflect the mean proportion of the PFA, expressed in percentage (%), comprised of each seral stage in the McGrath et al. (2003) study and each size class plus openings in all other studies (seedling/sapling = < 5" dbh; pole-sized = 5 to 8.9" dbh; mature and older = > 9.0" dbh). The proportion of the PFA comprised of pole and larger forest with > 50% canopy cover is also displayed for each study.

McGrath et al. (2003: Table 15) [1]			Reynolds et al. (1992) [2]	Patla (1997) [3]	Desimone (1997) [4]	Clough (2000) [5]	Range of Conditions
Mean % of (Standard Error) by Seral Stage		Mean %of (Standard Error) by Size Class					
Stand initiation	3.6 (0.9)	Seedling/ sapling	10	18.3 (3.0)	4.2 (1.7)	9.3 (2.9)	4 to 15
High stem exclusion	18.3 (2.0)	Pole-sized	20	20	15.3 (2.9)	65.7 (5.0)	18 to 61
Low stem exclusion	8.3 (1.4)						
High understory reinitiation	37.2 (2.0)	Mature and older forest	60	66.0 (4.0)	44.8	11.3 (2.6)	14 to 62
Low understory reinitiation	24.8 (2.2)						
Oldgrowth	0.9 (0.4)						
Pole/Mature with >50% canopy cover [6]	55.5		66		36.5 (4.9)	69	36 to 69
Wet openings	2.9 (0.4)	Openings	10	6.7 (2.2)		6.7 (2.2)	9 to 10
Dry openings	5.4 (1.1)						

[1] McGrath et al. (2003), northeastern Oregon and central Washington in the Blue Mountains and Eastern Cascade Provinces. Nests found in mixed conifer, Douglas-fir, ponderosa pine, western larch, lodgepole pine between 2388 and 6991 feet elevation that averaged 22 inches of precipitation per year.

[2] Reynolds et al. (1992), southwestern United States, management recommendations for ponderosa pine, mixed-conifer, and spruce-fir forests.

[3] Patla 1997, southeastern Idaho and western Wyoming including portions of the Middle and Northern Rocky Mountain Provinces. Goshawk nests were found in Douglas-fir, lodgepole pine, or mixed conifer forests between 6102 and 7923 feet elevation that averaged 16 to 24 inches of precipitation per year at the lower elevations.

[4] Desimone (1997), eastern Oregon, Blue Mountains Province. Nests found in ponderosa pine, mixed-conifer, and lodgepole pine (no elevational range or annual precipitation reported).

[5] Clough (2000), west central Montana, Middle Rocky Mountain Province. Nests were found in Douglas-fir, lodgepole pine, and mixed conifer forests between 5000 and 6601 feet elevation that averaged 14 inches of precipitation per year at lower elevations.

[6] B. Moser (pers. comm. September 18, 2006), Phd. dissertation in prep. at the University of Idaho at Moscow, based on telemetry data collected in northern Idaho, recommends maintaining at least 40% of the PFA in pole-sized or larger forest with high (> 50%) canopy cover, with at least 100 of those acres forming contiguous forest that encompasses the occupied nest site or nest stand.

● Foraging

McGrath et al. (2003: 48) show "the goshawk's reliance on specific habitat conditions for nesting decreases as distance from the nest increase." Hargis et al. (1994) during a three-year study of northern goshawks in California tracked eight female and two male northern goshawks equipped with radio transmitters that provide data on foraging habitats. The intent of the Hargis et al. (1994) study was to determine those features or landscape patterns that influence northern goshawk home range size and individual use. Hargis et al. (1994) concluded that an "emphasis should be placed on creating or maintaining vegetation diversity" (as compared to random sites) page 66) and "that timber harvests be designed to create a juxtaposition of seral stages, including mature timber, rather than large tracks of homogeneous, mid-seral stages" (page 73).

Given the Hargis et al. (1994) recommendation, a mix of seral stages similar to the PFA (Table 1) serve as a general description of desired goshawk foraging habitat. These recommendations should be considered as general in that the goshawk is a habitat generalist at the foraging area scale and opportunistic predator. Goshawk take prey items taken on the ground, on vegetation, in the air, and include tree squirrels, ground squirrels, rabbits, hares, songbirds, and grouse that rely on a variety of forested and non-forested habitats.

Project Analysis

All Forest Plan standards are met and documented.

Analysis is disclosed in the NEPA document that considers and discusses the quality and quantity of habitat necessary to support the goshawk utilizing available scientific habitat recommendations.

Considers and discloses any known goshawk population information, data or trend information available from monitoring sources, natural history databases etc.

Sets forth and applies a methodology for measuring the existing amount of the species habitat—e.g. applying a nest, PFA, and home range analysis—as described above for goshawk. The methodology used is supported by evidence that the methodology is reasonably reliable and accurate with reference to scientificand other sources relied upon.

Considers and discusses the amount of species habitat available at the Regional and/or Forest-wide level.

Discloses the impact of the project on the species habitat based on the above—including cumulative impacts—showing that no appreciable adverse habitat disturbance would result from the planned activity. The basis for the Forest Service's conclusion is adequately explained with reference to the factual basis for its analysis.

Addresses and includes discussion of any scientific uncertainty or credible opposing viewpoints raised in public comment concerning habitat recommendations, methodologies etc.

Appendix A provides an example of a project level analyses for a fuels reduction project that includes "drop in" language that tracks with Regional status and trend information, a discussion of recent opposing views in the literature, offers a means to analyze direct, indirect, and cumulative effects, and addresses viability/sustainability that is sensitive to recent court decisions. A recommended change is to use PFA information provided above. Foraging habitat can be analyzed by displaying the diversity of available habitats at the 5th field hydrologic unit code scale. Appendix B includes a check list relative to project level analysis.

During project level planning, it may be necessary to determine the presence of goshawks to determine whether activity restriction or habitat recommendations should be applied. The presence of goshawks can be determined by reviewing District/Forest/Grassland wildlife sighting records, reviewing District/Forest/Grassland wildlife monitoring records, and/or conducting field inventories for goshawks within the project area.

Summary

The northern goshawk occurs in a variety of forested environments. Overall, the goshawk is a habitat generalist, but may be more of a habitat specialist around the nest. While no demographic information suggests a decline in goshawk numbers, there are wide differences among geographic regions and scientific studies in understanding north goshawk habitat requirements. Based on these differences and the issues facing the Northern Region pertaining to the northern goshawk, this document was produced to provide regional management guidance to be used during project level planning and implementation to protect northern goshawks and their habitat. This document also provides habitat parameters that can be used to build a habitat relationship model at the project level (See Project Habitat Recommendations), as well as a list of items to consider when conducting project level analyses (See Project Analysis section).

Glossary of Terms

1. Active nest – A goshawk nest known to have contained an egg. A nest need not have successfully produced fledglings to be considered active.
2. Active nest area – An area containing an active goshawk nest within the last 10 years. An alternate nest area can be nest area that has been recently active or historical.
3. Adverse management activity – Any activity that could adversely modify goshawk behavior, reproductive effort, or habitat.
4. Alternative nest area – Goshawk home ranges often contain two or more nest areas, only one of which will be active in a given year. All alternative nest areas are historical nest areas.
5. Basal Area (BA) – Basal area is the cross section at breast height (4.5 feet above ground level) or at the root crown of a tree or trees, usually expressed as square feet per acre. A measure of stand density.
6. Breeding season – The period from March 1 through September 30, which includes courtship, incubation, nestling, and fledgling-dependency periods.
7. Canopy closure (synonymous with canopy cover) – the percentage of ground area shaded by overhead foliage.
8. Cover type – The current or existing vegetation of an area, based on the predominant vegetation species.
9. Diameter at breast height (DBH) - The outside bark diameter of a tree measured at breast height, 4.5 feet above the forest floor on the uphill side of the tree.
10. Dominant tree – The tallest tree in a forest. Together with the codominants, the dominant trees comprise the main canopy of the stand.
11. Failed nest – An active nest in which the eggs or nestlings are lost (e.g., to predators, weather) or abandoned by the adult(s). No young fledged.
12. Fledgling – A young bird that has left it’s nest but is unable to completely care for itself.
13. Fledgling-dependency period – The period beginning when the young leave the nest to when they are no longer dependent upon adults for food (about 30-60 days for goshawks).
14. Foraging habitat – Areas where prey are searched for, pursued by and captured by goshawks.

15. Habitat security – The protection inherent in any situation that allows wildlife to remain in a defined area despite an increase in stress or disturbance associated with human activity. Habitat security is area specific.
16. Historical nest – A nest known to have been active more than 10 years from the present time.
17. Historical nest area – A nest area containing one or more historical nests. An alternate nest area can be a historical nest area.
18. Home Range – The area that an animal habitually uses during nesting, resting, bathing, foraging and roosting. Adjacent pairs of goshawks may have overlapping home ranges; the extent of which is typically unknown. A nesting home range contains nest areas (active and historical), the post fledgling area, and the surrounding foraging habitat.
19. Mesic – Moderate moisture conditions, rather than hydric (wet) or xeric (dry) conditions.
20. Multi-storied stand - A forest stand having more than one horizontal layer of vegetation.
21. Nest – A platform of sticks, duct tape, crazy glue and old seat cushions on which eggs are laid. Most goshawk nests are placed within the lower two-thirds of tree crowns, often against the trunk but occasionally on a limb up to 10 feet from the trunk, good for bow hunting.
22. Nest area – The nest tree and stand(s) surrounding the nest that contain prey handling areas, perches, and roosts. Nest areas are often on cool and mesic sites (northerly facing slopes).
23. Nest attempt – An attempt to nest. Evidence of courtship behavior in a nest area, new nest construction, reconstruction of an old nest, eggs or nestlings.
24. Nest stand – The stand of trees that contains the nest tree.
25. Nest tree – The tree containing the nest.
26. Nesting season – The period from the beginning of courtship behavior until the fledgling(s) are no longer dependent on adults for food.
27. Post-fledgling area – The area of concentrated use by the goshawk family after the young leave the nest.
28. Replacement nest area – Forest areas with physiographic characteristics and size(s) similar to suitable nest areas. Replacement areas can have young to mature forests that can develop into suitable nest areas.
29. Roost – Trees or groups of trees used by birds or mammals for resting. A roost site consists of all other trees whose crowns overlap or interlock with the roost tree.
30. Single-storied stand – A stand of trees having a single canopy layer.
31. Stand – An area of trees possessing sufficient uniformity to be distinguishable from trees in adjacent areas.
32. Successful nest – A nest from which at least one young is fledged.
33. Suitable habitat - Habitat that is currently useable for nesting, roosting and foraging. Habitat need not be occupied to be considered suitable.
34. Suitable nest area – An area that includes all the attributes of a nest area and is, therefore, useable for nesting.
35. Territory – An exclusive area defended by goshawks. An active nest is not an essential element of a territory.
36. Understory – Any layer of the forest canopy below the overstory; can consist of trees, shrubs and/or herbaceous layers.
37. Unsuitable habitat – Habitat that does not have the capability of attaining the characteristics of suitable habitat through standard, prescribed management treatments or natural processes.

Definition Sources

Daubenmire, R. 1959. A canopy-coverage method of vegetation analysis. Northwest Sci. 33:43-64.

Ganey, J.L. and W.M. Block. 1994. A comparison of two techniques for measuring canopy closure. Western Journal of Applied Forestry, Vol. 9, No. 1, January 1994.

Reynolds, R.T., et al. 1992. Management recommendations for the northern goshawk in the southwestern United States. USDA For. Serv. Gen. Tech. Rep. RM-217.

Literature Cited

Andersen, D. E., S. DeStefano, M. I. Goldstein, K. Titus, C. Crocker-Bedford, J. J. Keane, R. G. Anthony, and R. N. Rosenfield. 2004. The status of northern goshawks in the western United States. Wildlife Society Technical Review 04-01. The Wildlife Society, Bethesda, Maryland, USA.

Clough, L. T. 2000. Nesting habitat selection and productivity of northern goshawks in west-central Montana. Missoula, MT: University of Montana. M.S. Thesis. 87 pp.

DeSimone, S.M. 1997. Occupancy rates and habitat relationships of Northern Goshawks in historic nesting areas in Oregon. Master's thesis, Oregon State University, Corvallis, OR.Hargis, C. D., C. McCarthy, and R. D. Perloff. 1994. Home ranges and habitats of Northern Goshawks in eastern California. Studies in Avian Biology 16: 66-74.

Joy, S. M. 2002. Northern goshawk habitat on the Kaibab National Forest in Arizona: factors affecting nest locations and territorial quality. Dissertation, Colorado State University, Fort Collins, Colorado, USA.

Kennedy, P.L., J.M. Ward, G.A. Rinker, and J.A. Gessaman. 1994. Post fledgling family areas in Northern Goshawk home ranges. Stud. Avian Biol. 16:75-82.Kennedy, P. L. 2003. Northern goshawk (*Accipiter gentilis atricapillus*): a technical conservation assessment. Unpublished report, USDA Forest Service, Rocky Mountain Region, Species Conservation Project, Denver, Colorado, USA.

Kowalski, S. 2006. Frequency of northern goshawk presence in the northern Region. Unpublished report on file in USDA For. Serv., Region One, Missoula MT. (to be added to http://www.fs.fed.us/biology/ wildecology/goshawk.html)

McGrath, M. T., S. DeStefano, R. A. Riggs, L. L. Irwin, and G. J. Roloff. 2003. Spatially explicit influences on Northern Goshawk nesting habitat in the interior Pacific Northwest. Wildlife Monographs 154:1–63.

Patla, S.M. 1997. Nesting ecology and habitat of the northern goshawk in undisturbed and timber harvest areas on the Targhee National Forest, Greater Yellowstone Ecosystem. M.S. Thesis, Idaho State Univ., Pocatello, ID. 164pp.

Penteriani, V., and B. Faivre. 2001. Effects of harvesting timber stands on goshawks in two European areas. Biological Conservation 101: 211-216.

Reich, R. M., S. M. Joy, and R. T. Reynolds. 2004. Predicting the location of northern goshawk nests: modeling the spatial dependency between locations and forest structure. Ecological Modeling 176:109-133.

Reynolds, R. T., R. T. Graham, M. H. Reiser, R. L. Bassett, P. L. Kennedy, D. A. Boyce, G. Goodwin, R. Smith, and E. L. Fisher. 1992. Management recommendations for the Northern Goshawk in the Southwestern United States. General Technical Report RM-217, 90 pp. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO, USA.

Reynolds, R.T., R.T. Graham, and D.A. Boyce. 2005. Habitat conservation of the northern goshawk in the southwestern united states: response to Greenwald et al., report dated December 18, 2005, Final Supplement to the Final Environmental Impact Statement (FEIS) for Amendment of Forest Plans, USDA Forest Service, Southwestern Region, Albuquerque, NM.

Salafsky, S. R., R. T. Reynolds, and B. R. Noon. 2005. Patterns of temporal variation in goshawk reproduction and prey resources. Journal of Raptor Research 39: 237-246.

Samson, F. B. 2006a. (www.fs.fed.us/r1/projects/wlfecology; Accessed June 29, 2006). A Conservation assessment of the northern goshawk, blacked-backed woodpecker, flammulated owl, and pileated woodpecker in the Northern Region, USDA Forest Service. Unpublished report on file, Northern Region, Missoula, Montana, USA.

Samson , F. B. 2006b. (www.fs.fed.us/r1/projects/wlfecology; Accessed June 29, 2006). Habitat estimates for maintaining viable populations of the northern goshawk, black-backed woodpecker, flammulated owl, pileated woodpecker, American martin, and fisher. Unpublished report on file, Northern Region, Missoula, Montana, USA.

Squires, J. R., and R. T. Reynolds. 1997. Northern Goshawk. No. 298. In The birds of North America. The Academy of Natural Sciences, Philadelphia, Pennsylvania, and The American Ornithologists' Union, Washington, DC, USA.

Squires, J. R., and P. L. Kennedy. 2006. Northern goshawk ecology: an assessment of current knowledge and information needs for conservation management. Studies in Avian Biology 31: 8-62.

USDI Fish and Wildlife Service. 1998. Status review of the northern goshawk in the forested west. Portland, Oregon, USA.

Whitford, T.C. 1991. Defining old-growth Douglas-fir forests of central Montana and use of the Northern Goshawk (*Accipiter gentilis*) as a management indicator species. Master's thesis, University of Montana, Missoula, MT.Woodbridge, B., and C. D. Hargis. 2005. Northern goshawk inventory and monitoring technical guide. USDA Forest Service, Washington Office, Ecosystem Management Coordination Staff, Wildlife, Fish, Watershed, and Air Staff, Washington DC, USA.

Younk, J.V., and M.J. Bechard. 1994. Breeding ecology of the Northern Goshawk in high elevation aspen forests of northern Nevada. Stud. Avian Biol. 16:119-121.

Habitat Estimates for the northern goshawk using the model described above (i.e., Table 1).

Forest	Habitat (ha)
Beaverhead-Deerlodge	142,206
Bitterroot	16,031
Idaho Panhandle	59,085
Clearwater	25,096
Custer	14,657
Flathead	13,942
Gallatin	40,460
Helena	46,869
Kootenai	28,641
Lewis and Clark	67,856
Lolo	23,629
Nez Perce	106,728